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Application guidance on running climate change materiality assessment and using climate change scenarios in the ORSA

EIOPA-BoS-22/329
02 August 2022

European Insurance and Occupational Pensions Authority

INTRODUCTION

This application guidance is a follow-up from EIOPA's Opinion on the supervision of the use of climate change risk scenarios in ORSA ("Opinion") published in April 2021 (EIOPA-BoS-21-127 - EIOPA, 2021a). The Opinion was addressed to the national competent authorities on the basis of Article 29(1)(a) of Regulation (EU) No 1094/2010 and aims to enhance supervisory convergence.

The Opinion sets out supervisory expectations on the integration of the use of climate change scenarios by insurance undertakings in their Own Risk and Solvency Assessment ORSA. Given that undertakings will be impacted by climate change-related physical and transition risks[1], EIOPA believes it is important to encourage a forward-looking management of these risks, also in the long term. Currently, only a small minority of undertakings assess climate change risk using scenario analysis in the ORSA. Moreover, where undertakings perform a quantitative analysis of climate change risk, most assessments take a short-term perspective.

During the public consultation of the Opinion, nearly all respondents provided comments and suggestions on the application guidance for developing and including climate change risk scenarios in ORSA (Annex 5 of the Opinion).

EIOPA therefore decided to elaborate on application guidance, seeing the advantages of developing and providing optional guidance for materiality assessment in the context of climate change, climate change scenario design and specifications using concrete case studies. This would also contribute to lowering implementation costs for insurance undertakings, in particular small- and mid-sized ones, and to enhancing the comparability of reported information.

This application guidance is not a supervisory convergence tool in the meaning of Article 29 of Regulation (EU) No 1094/2010. This paper provides initial aid for undertakings to conduct such

[1] Climate change constitutes a serious risk for society, including insurance and reinsurance undertakings. The detrimental impact of global warming on natural and human systems is already visible today and without further international climate action, the global average temperature and associated physical risks will continue to increase, raising underwriting risk of undertakings, impacting asset values and challenging their business strategies. The Paris Agreement on climate change requires its signatories to reduce greenhouse gas emissions with the objective to hold the global temperature increase to well below 2°C and to pursue efforts to limit it to 1.5°C compared to pre-industrial levels. Keeping the global temperature increase below 2°C would require annual reductions in carbon emissions greater than occurred in any single year in the last 100 years, including during the deepest recessions, and 70-80% of proven fossil fuel reserves to be stranded. Hence, the transition towards a zero-carbon economy, especially when unanticipated, may seriously depress investments in carbon-intensive sectors. The transition may also induce higher legal claims on companies that fail to take into account the impact on climate change, which may affect undertakings directly or indirectly through their underwriting of legal liability risks.

analysis on climate change in the ORSA[2]. The undertakings should not restrict themselves to the aspects covered in this application guidance. Due to specific portfolios, undertakings might want to explore other alternatives to look at climate change risks.

EIOPA would also like to thank the NGFS[3], 2DII[4] and RMS[5] for their help with examples shown in this paper. These tools were chosen as this paper also uses previous analysis shown for example in EIOPA's sensitivity analysis (EIOPA, 2020). Additional tools, data and methods might be available to run materiality assessment and climate change scenarios.

In September 2021, the European Commission published a proposal for a directive amending Directive 2009/138/EC (Solvency II). Some of the proposals consist of amendments related to the European Green Deal. In particular, paragraph 25 of Article 1 of that directive introduces the new Article 45a on climate scenario analysis. The new provisions establish that undertaking will have to identify any material exposure to climate change risks and, where relevant, assess the impact of long-term climate change scenarios on their business, in their ORSA. Undertakings classified as low-risk profile undertakings are exempted from scenario analyses.

HOW TO READ THE APPLICATION GUIDANCE?

For a high-level reader (~20 pages):

- Chapter 1 describes the different parts in the ORSA where undertakings have the possibility to address climate change risks.
- Chapter 2 provides general insights on the materiality assessment and climate change scenarios.

For a technical user (~100 Pages):

- In addition to Chapters 1 and 2, Chapter 3 gives concrete examples using both dummy non-life and life companies on materiality assessment and running climate scenarios.

[2] Note also that most of the analysis did not consider the impact of reinsurance to simplify the analysis. However, reinsurance can have a significant impact and should be considered were relevant.

[3] NGFS Scenarios Portal

[4] 2DII - Aligning financial markets with the Paris Agreement goals (2degrees-investing.org)

[5] Risk Management Models, Analytics, Software & Services | RMS

DUMMY COMPANIES

As a starting point, EIOPA has constructed "dummy" life and non-life companies[6] to produce concrete examples and make this exercise more relevant for undertakings to use when assessing their exposure to climate change risk in the ORSA. These dummy companies will help to design the steps for the materiality assessment and to run climate change scenarios. Note that the examples used for the non-life companies could also be relevant for a life company and vice versa, undertakings are therefore encouraged to look at all examples.

The dummy non-life company comprises of solo undertakings, which are most exposed to natural catastrophe risks due to the business written. An average of the values of these undertakings was calculated with significant rounding and simplifications applied afterwards to create the "dummy" company. The balance sheet, underwriting portfolio and risk profile as well as the country exposures by peril of this dummy company is assessed.

Following a similar approach as for the dummy non-life company, the dummy life average portfolio has been built from a selection of undertakings which could potentially show a high exposure to transition risk. The selection criteria have been both size (as the objective of the exercise is to target small medium firms) and asset exposure in climate related sectors, using as input the Quantitative Reporting Templates (QRT S06.02).

The description of the dummy companies can be found in Annexes 1 and 2.

[6] Note that these dummy companies are only used for illustrative purposes, undertakings should use their own exposure.

1. THE ORSA AND CLIMATE CHANGE

Insurance undertakings conduct an own risk and solvency assessment (ORSA) as part of their risk management. Such assessment provides insight into the overall solvency needs, the undertaking's compliance with underlying capital requirements and the significance with which the risk profile of the undertaking deviates from the assumptions on which these requirements are based.

Climate change risk can translate into physical and transition risk, and can have material impact on the undertakings[7]. Given the potential impact, undertakings are expected to integrate climate change risks into their ORSA by describing and assessing the impact of these risks on their risk profile.

In this assessment, undertakings have the possibility to address climate change risks in different parts of the ORSA such as:

- Management or executive summary; either (i) highlights how climate change risks are covered in the body of the ORSA or (ii) briefly summarizes the major findings and conclusions (or recommendations) on climate change- risks.
- Introduction; describes the parts of the ORSA in which climate change risks are addressed.
- Undertaking's vision and strategy; describes the route an undertaking intends to take in developing and strengthening its business. Climate change risks and business opportunities can be part of the lay out of the undertaking's strategic course in preparing for the future[8].
- Undertaking's risk appetite or risk profile; climate change risk can be identified when defining the undertaking's risk appetite or risk profile.
- Risk assessment; climate change risks can be identified as risks that are not addressed in the standard formula and considerations can be given about ways to control these risks.
- Scenario analysis; climate change risks can be part of scenario analysis on to what extent the undertaking is at risk and whether the undertaking is able to absorb possible climate change shocks (worst cases).
- Management actions; statement on corrective action to address climate change risks.

[7] Direct physical and transition risks can be amplified by the cost related to climate litigation, in some frameworks represented as a separate risk but subsumed here under physical and transition risk.

[8] This should also be in line with the undertakings' communication to external parties.

- Conclusions; statement of the essential findings on climate change risks.

A good practice is to address climate change risks in more than one (sub) chapter of the ORSA-report. It is also encouraged to mention to what extent the impact of climate change risks has been analyzed in previous years.

In researching the impact of climate change risks, it can be useful to distinguish between physical and transition risks[9] and explain (by means of examples) their assessed impacts in the short, medium and long term.

[9] Recognizing also the role of litigation risks

2. GENERAL INSIGHTS

MATERIALITY ASSESSMENT

A first step when considering climate change risks in the ORSA is to assess the materiality. The Opinion mentions that CAs should expect undertakings to identify material climate change risks for their business (section 3.8 of the Opinion), and undertakings, which conclude that climate change is not a material risk, to provide an explanation as to how that conclusion has been reached (section 3.14 of the Opinion) (EIOPA, 2021a) (De Nederlandsche Bank (DNB), 2019). Risks are considered to be material in the context of Solvency II where ignoring the risk could influence the decision-making or the judgement of the users of the information, which in case of the ORSA would be the undertaking's administrative, management or supervisory body and its relevant staff[10]. CAs should expect undertakings to identify the materiality of exposures to climate change risks through a combination of qualitative and quantitative analyses.

In order to conduct such a materiality assessment, the following steps could be considered by the undertakings:

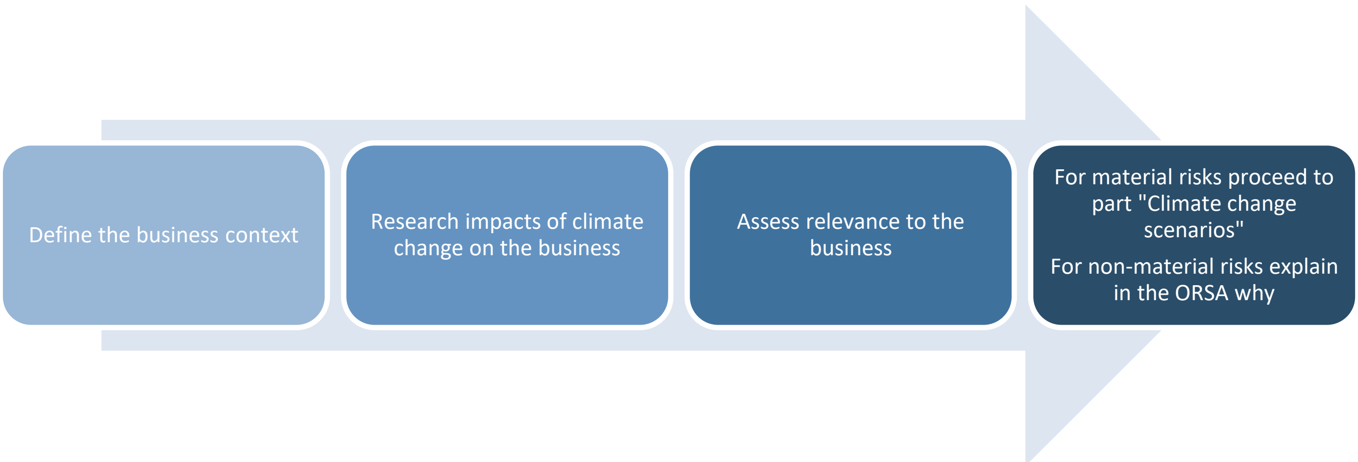


Figure 1: Steps to conduct a materiality assessment

(i) Defining the business context

[10] Article 305 of the SII Delegated Regulation

In the first step the undertaking can define the context where they would be exposed to climate change risks. Undertakings could for example describe the impacted LoBs and/or insurance activities, the time horizon considered, the strategic context…

(ii) Researching impacts of climate change on the business

In the second step the undertaking is researching what the possible impacts of climate change risks on their exposure could be. In this step a distinction can made between transition and physical risk[11]. The undertaking elaborates consequently on the possible effects for e.g its insurance products offered or balance sheet. In this step it does not matter whether the effects are material or not.

(iii) Assessing relevance to the business

In the third step the undertaking is assessing the materiality of each climate change risk on both sides of the balance sheet. The materiality should consider the size of the undertaking's exposure, the impact of climate change on the specific exposure, the probability that the impact will take place. The materiality assessment could be summarized in a so-called materiality matrix (see part 2.1).

BALANCE SHEET AND SCR IMPACTED BY CLIMATE CHANGE

Both sides of the balance sheet, the assets and liabilities can be impacted by physical risks and/or transitions risks. The market value of assets, the technical provisions as well as the Solvency Capital Requirement (and Minimum Capital Requirement) could be impacted by climate change.

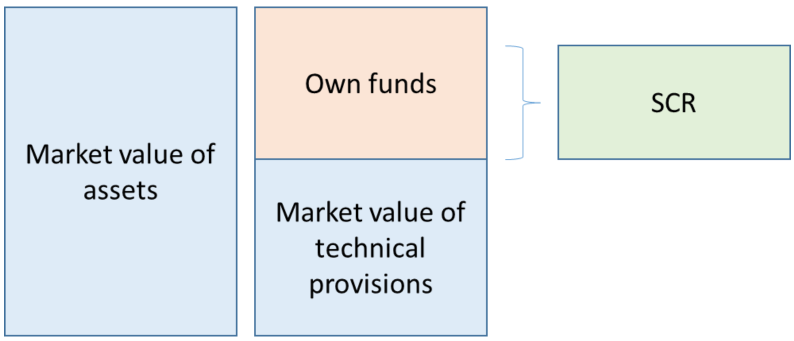


Figure 2: Simplified balance sheet

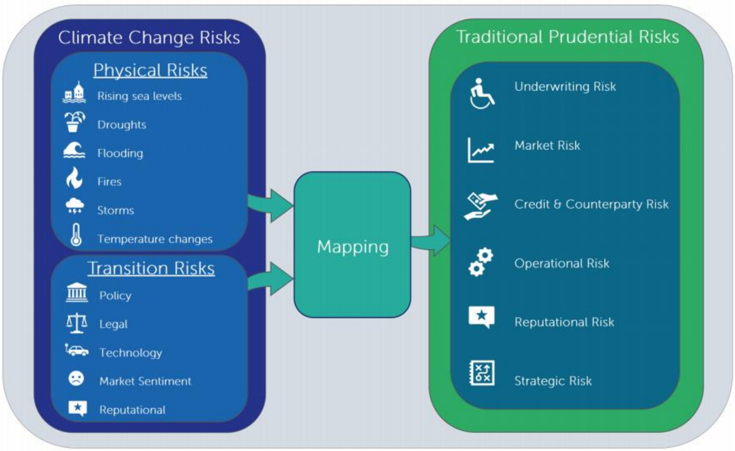
[11] Also considering the impact of litigation risks.

For example for the technical provisions, climate change is expected to impact the future claims cost of the undertakings through introducing further uncertainty in the assumptions but also through changes in:

- Frequency and severity of risks of extreme events (physical risk – acute/chronic)
- Potential lawsuits and future claim environment and claim propensity as well as court precedents (transition risk - legal risk, from now on litigation risk)

The impact on the underlying LoBs will be different due to the nature of the product and differences in exposure characteristics and perils covers (see Annex 4).

Annexes 3 and 4 of the Opinion (EIOPA, 2021a) provides a holistic view of how climate change risks could impact different prudential risks (see also illustrations in Figure 3 below – note that these are just examples).



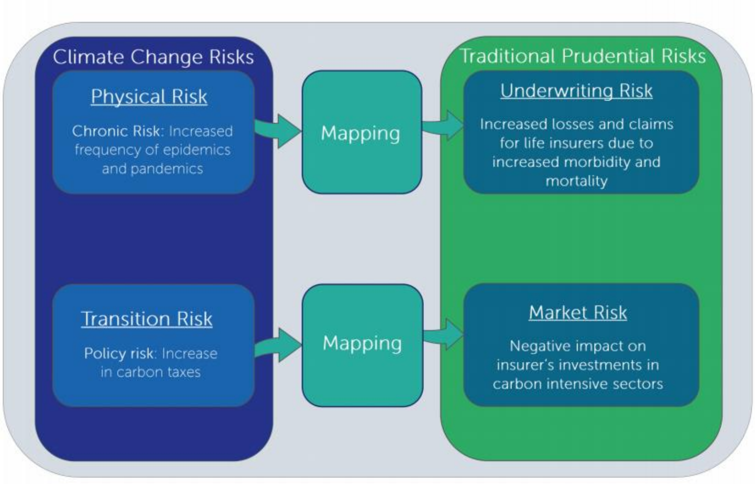


Figure 3: Examples of mapping climate to prudential risks (i.e. market risk, counterparty risk, underwriting risk, operational risk, reputational risk and strategic risk[12]). Source: Finalyse "Climate change risks in the ORSA"[13]

Despite the fact that the impact from physical and transition risks (see definition in box below) on the balance sheet are often assessed separately, these risks can be seen as part of the same analysis and as being interconnected.

[12] Operational risk is the risk of loss arising from inadequate or failed internal processes, or from personnel and systems, or from direct exposure to climate risks with its operational procedures affected.

The Counterparty default risk module reflects possible losses due to unexpected default, or deterioration in the credit standing, of the counterparties and debtors of (re-) insurance undertakings.

Market risk relates to uncertainty in the level or volatility of market prices of financial instruments due to significant stranded assets.

Underwriting risk relates to the uncertainty in results of the insurer's underwriting.

Reputational risk that adverse publicity regarding an insurer's business practices and associations, whether accurate or not, will cause a loss of confidence in the integrity of the institution.

Strategic risks arising from strategic decisions.

[13] Webinar: Climate change risk scenarios in the ORSA | Society of Actuaries in Ireland

Box: Definition of transition and physical risks (EIOPA, 2021a)

Transition risks are risks that arise from a rapid transition to a low-carbon and climate-resilient economy. They for example include:

- Policy risks, for example as a result of energy efficiency requirements, carbon-pricing mechanisms which increase the price of products which are using fossil fuels.
- Legal risks, for example the risk of litigation for failing to avoid or minimise adverse impacts on the climate, or failing to adapt to climate change.
- Technology risks, for example if a technology with a less damaging impact on the climate replaces a technology that is more damaging to the climate.
- Market sentiment risks, for example if the social norms and choices of consumers and business customers shift towards products and services that are less damaging to the climate.
- Reputational risks, for example the difficulty of attracting and retaining customers, employees, business partners and investors if a company has reputation for damaging the climate.

Physical risks are risks that arise from the physical effects of climate change. They include:

- Acute physical risks, which arise from particular events, especially weather-related events such as storms, floods, fires or heatwaves that may damage production facilities and disrupt value chains.
- Chronic physical risks, which arise from longer-term changes in the climate, such as temperature changes, rising sea levels, reduced water availability, biodiversity loss and changes in land and soil productivity.

TIME HORIZON

The Opinion mentions that CAs should also expect undertakings to assess the long-term risks of climate change using scenario analysis to inform the strategic planning and business strategy, if this risk is material[14] (EIOPA, 2021a). The time horizon could be longer than the time horizons currently considered by undertakings in their ORSA, e.g. an order of magnitude of decades may be appropriate. In contrast to the usual expectation of short-term, mid-term and long-term time

[14] Article 45(4) of the Solvency II Directive.

horizons in the ORSA, time horizons from a climate change perspective tend to be considerably longer (EIOPA, 2021b).

The difficulty when considering climate change in the ORSA is to reconcile the fact that the time horizon used in the context of climate change is much longer than the usual “business” time horizon used by undertakings in the ORSA.

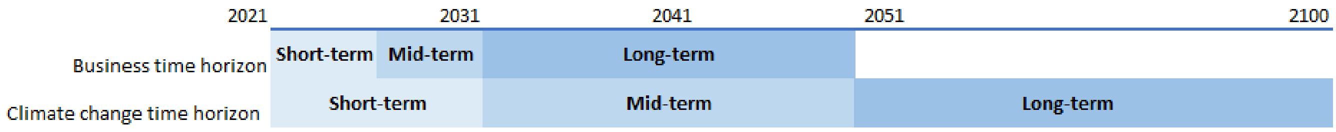


Figure 4: Example of business and climate change time horizon

For most climate change risk analyses currently done in the ORSA, the time period considered was 1-5 years or not specified.

However, undertakings should also think that different insurance activities require different time horizons as shown in Table 1 below. Table 1, as an example, below considers the following time horizons:

- Short term projection: 1-5 years, which is the period during which boards typically operate to develop risk appetite, strategy and business plans.
- Medium term projection: 5-10 years, which is the period that the viability of new products would need to be tested against.
- Long term projection: 10-years or more.

Motivation to undertake climate change analysis	Time horizon	Example of firm functions impacted
Disclosure: TCFD[1] related	Long	Corporate and Social Responsibility, Finance and Risk, Finance, Actuarial, Sales, Marketing, Exposure Management
Disclosure: Public reporting (eg shareholders)	Medium, Long	Finance, Actuarial, Exposure Management, and Risk
Disclosure: Public policy advocacy	Long	Corporate and Social Responsibility, Finance, and Risk
Business decision: Underwriting and pricing	Short	Sales, Marketing, Underwriting, Finance, Exposure Management, and Actuarial
Business decision: Capital	Short	Claims, Finance, Actuarial, Exposure Management, and Risk
Business decision: Outwards risk transfer (eg reinsurance purchase)	Short	Underwriting, Finance, Actuarial, Exposure Management, and Risk
Business decision: Product development	Medium, Long	Sales, Marketing, Underwriting, Claims, Finance, Actuarial, Exposure Management, and Risk
Business decision: Business Plan	Medium	Sales, Marketing, Underwriting, Finance, Actuarial, Exposure Management, and Risk
Business decision: Risk management, including risk appetite setting	Medium, Long	Underwriting, Finance, Actuarial, Exposure Management, and Risk

Table 1: Example business decisions, forms functions impacted and the time horizons over which they are considered (PRA, 2019). [1]Task Force on Climate-related Financial Disclosures.

The challenge is to reconcile the very long-term dynamics of climate change with the operational ability to assess the impact of related risks based on the company's current business model and this might require a new approach in the ORSA for the analysis of climate change risks.

While the long-term horizon of global warming trajectories is generally the end of the century, the long-term horizon of the resulting impacts and risks can be assessed by the company over the next 15 to 30 years as suggested in EIOPA paper on *"Methodological Principles of Insurance Stress Testing – Climate Change Component"*.

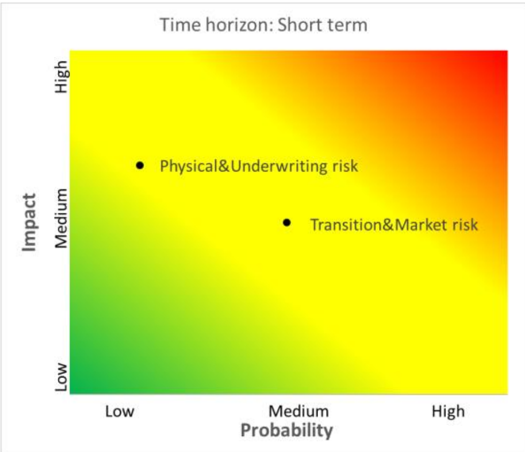
In any case, the time horizon for analysing climate change risks should be consistent with the company's long-term commitments.

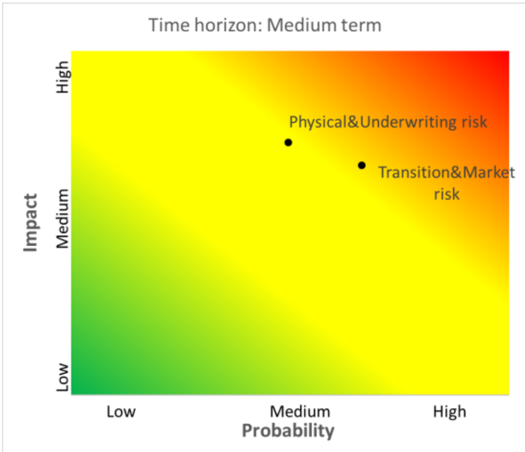
MATERIALITY ASSESSMENT MATRIX

In order to perform the materiality assessment, three dimensions could be considered, the impact, the probability and time horizon. The consideration of the impact of climate change and corresponding probability for different time horizons is important as climate change is expected to have different impacts with time. Undertakings should think of the impact of climate change beyond the typical short-term horizon. In addition, some climate change risks already materialise in the short-term.

Undertakings could use the results from the analysis made on how climate change would impact the balance sheet and show it in a materiality assessment matrix as shown in Figure 5. This allows to see how the risk is evolving with time and also for which time horizon it is more relevant. It also has the advantage of providing a forward-looking view.

The mapping between climate change risks (physical or transition risks) and which aspects would be impacted in the balance sheet could be done in the materiality matrix, and could also be represented from an impact and probability of occurrence point of view. Note that the below illustration are done at high level. Undertakings could decide to show the analysis at a higher degree of granularity (e.g. flood risk in Germany instead of physical and UW risk).





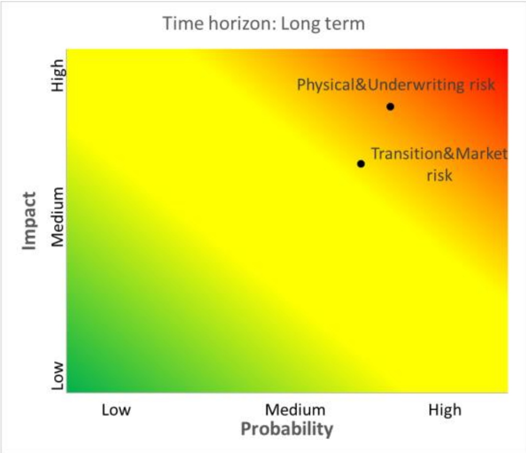


Figure 5: Example of materiality matrices for different time horizons.

CLIMATE CHANGE SCENARIO

For material risks, the Opinion expects undertaking to run climate change scenarios. The steps could be the following:

Figure 6: Steps to conduct a scenario analysis.

SCENARIOS

In line with the Opinion (section 3.18), undertakings are expected to consider at least two long-term climate scenarios (subject to material climate change risks), where appropriate:

- a climate change risk scenario where the global temperature increase remains below 2°C, preferably no more than 1.5°C, in line with the EU commitments; and

- a climate change risk scenario where the global temperature increase exceeds 2°C.

The below analyses also consider shorter-term scenarios as they will also be relevant for the businesses.

(Climate change) Transition scenarios

Transition scenarios define different views on the future decarbonization of the economy and associated trends and be used in the context of transition risk modelling. Choosing such scenarios involves the following steps (2DII, 2017):

1. Define high-level scenario needs. Assessing transition risk requires specific scenarios that reflect transition trends. These are in particular the energy-technology scenarios developed by the IEA and other modelling agencies. Such scenarios can then be enriched (next step) to inform transition risk assessment.

2. Define the needed scenario parameters. The second step after choosing the type of scenario requires defining the specific scenario parameters. Specifically, key parameters include:

- Macroeconomic trends (e.g. GDP, inflation, other potential economic shocks);
- Policy costs and incentives (e.g. feed-in tariff, carbon tax, etc.);

- Market pricing (e.g. oil & gas prices, battery costs, etc.);
- Production & technology (e.g. oil production, power generation, electric vehicle sales);
- Legal and reputational (e.g. litigation costs, reputational shocks);

3. Choose the scenario ambition. Risk management requires a view on the future. Climate-related transition scenarios can thus involve different levels of ambition and views on how the objective is achieved. Notable types are 'business as usual' (e.g. 6°C warming), 'soft decarbonization' (e.g. 3-4°C warming) or 'ambitious decarbonization' (e.g. 2°C or less warming). Each of these scenarios are associated with different probabilities around achieving a range of degrees of warming.

4. Choose the scenario speed. Finally, one critical distinguishing feature in scenarios is the assumption around the speed or 'disruptiveness' / non-linearity of the transition. This element is important for risk assessment as more sudden, abrupt impacts are likely to create more significant risks than 'smooth' transitions.

(Climate change) Physical scenarios

Climate change scenarios explore the possible consequences of human activities on the climate system according to different changes in socio-economic systems.

First the "Representative Concentration Pathways" (RCPs) were developed, describing different levels of greenhouse gases and other radiative forcings that might occur in the future. Four pathways were developed, spanning a broad range of forcing in 2100 (2.6, 4.5, 6.0, and 8.5 watts per meter squared), but purposefully did not include any socioeconomic "narratives" to go alongside them[15].

Description of IPCC RCPs:

- Scenarios RCP8.5 is the high-emissions scenario, consistent with a future with no policy changes to reduce emissions, and characterized by increasing GHG emissions that lead to high atmospheric GHG concentrations. It is aligned broadly with a Current Policies or Business-As-Usual Scenario.
- RCP6.0 is a high-to-intermediate emissions scenario where GHG emissions peak at around 2060 and then decline through the rest of the century.
- RCP4.5 is an intermediate-emissions scenario, consistent with a future with relatively ambitious emissions reductions and GHG emissions increasing slightly before starting to decline circa 2040. Despite such relatively ambitious emissions reduction actions,

[15] Explainer: How 'Shared Socioeconomic Pathways' explore future climate change - Carbon Brief

RCP4.5 falls short of the 2°C limit/1.5°C aim agreed on in the Paris Agreement. It is aligned broadly with the GHG emissions profile that would result from implementation of the 2015 NDCs (out to 2030), followed rapidly by peaking and then reduction of global emissions by 50% by 2080.

- RCP2.6 is the only IPCC scenario in line with the Paris Agreement's stated 2°C limit/1.5°C aim. This RCP is consistent with ambitious reduction of GHG emissions, which would peak around 2020, then decline on a linear path and become net negative before 2100.

The following key parameters are considered for the different RCP scenarios (van Vuuren, 2011):

Scenario Component	RCP2.6	RCP4.5	RCP6	RCP8.5
Greenhouse gas emissions	Very low	Medium-low mitigation Very low baseline	Medium baseline; high mitigation	High baseline
Agricultural area	Medium for cropland and pasture	Very low for both cropland and pasture	Medium for cropland but very low for pasture (total low)	Medium for both cropland and pasture
Air pollution	Medium-Low	Medium	Medium	Medium-high

Table 2: Main characteristics of each RCP (van Vuuren, 2011).

In addition, "Shared Socioeconomic Pathways" (SSPs) were developed to model how socioeconomic factors may change over the next century. The SSPs look at five different ways in which the world might evolve in the absence of climate policy and how different levels of climate change mitigation could be achieved when the mitigation targets of RCPs are combined with the SSPs (Riahi et al., 2017). The box below is a summary of the five pathways.

SSP1 Sustainability – Taking the Green Road (Low challenges to mitigation and adaptation)

The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.

SSP2 Middle of the Road (Medium challenges to mitigation and adaptation)

The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.

SSP3 Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation)

A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

SSP4 Inequality – A Road Divided (Low challenges to mitigation, high challenges to adaptation)

Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle and high income areas.

SSP5 Fossil-fueled Development – Taking the Highway (High challenges to mitigation, low challenges to adaptation)

This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

The two efforts were designed to be complementary. The RCPs set pathways for greenhouse gas concentrations and, effectively, the amount of warming that could occur by the end of the century. Whereas the SSPs set the stage on which reductions in emissions will – or will not – be achieved.

While the RCPs were finished in time to be used in the IPCC Fifth Assessment Report (IPCC, 2013), developing the more complex SSPs has been a much longer and more involved process. The SSPs were initially published in 2016, but are only now just starting to be used in the next round of climate modelling – known as the Coupled Model Intercomparison Project version 6, or CMIP6 – for the IPCC's sixth assessment report (IPCC, 2021)[16].

TRANSFORMING SCENARIOS INTO CLIMATE CHANGE RISKS

Transition risks

Different transition scenarios will results in different transition risks. Transitioning away from fossil fuels and carbon-intensive production and consumption requires significant shift towards emissions-neutral alternatives in all sectors.

The energy transition required by the policy shock will impact companies' revenues and expenses, with the amplitude of the effect varying depending on the sector and market in which they operate. These changes in the companies' profits will subsequently impact their market value.

For example, a key driver of transition risk is the future pathway of fossil fuel prices and volumes, with potential spill-over effects to the broader economy.

[16] Explainer: How 'Shared Socioeconomic Pathways' explore future climate change - Carbon Brief

NGFS developed a set of transition pathways which seem particularly relevant for climate change related risks:

- Early policy action, **orderly transition scenario** where the transition to a carbon-neutral economy starts early and the increase in global temperature stays below 2^{o}C, in line with the Paris Agreement. Physical and transition risks are minimized in this scenario;

- Late policy action, **disorderly transition scenario** where the global climate goal is met but the transition is delayed and must be more severe to compensate for the late start. In this scenario, physical risks arise more quickly early on and transition risks are particularly pronounced compared to the early policy action scenario;

- **Too little, too late scenario**, where the manifestation of physical risks spurs disorderly transition, but not enough to meet Paris agreement goals. Physical and transition risks are both high and severe;

- **Business as usual**, no additional policy action scenario ('Hot house world') where no policy action which has already been announced is delivered. Therefore, the transition is insufficient for the world to meet the Paris agreement climate goal and physical risks will be particularly pronounced.

Physical risks

Different GHG emission pathways will result into different physical risks. Based on an RCP chosen as an input, a climate change scenario describes changes in the climate system and its variables such as temperatures, winds and rainfall, for a given time horizon and geographical area.

For example, the rise in temperature leads to increased heavy precipitation across many regions of the world, which in turn increases risks from flooding (IPCC, 2014). It is also changing the frequency and severity of severe weather events such as heatwaves, droughts, wildfires, tropical cyclones...

In order to transform GHG emission pathways into physical risks, general circulation models (GCMs) are used. A GCM is a numerical representation of the climate system, its components and their interactions. It draws in particular on the laws of physics. GCM can thus be used to simulate future climate change based on the RCPs used as input assumptions. The result will be changes in rainfalls, extreme events…

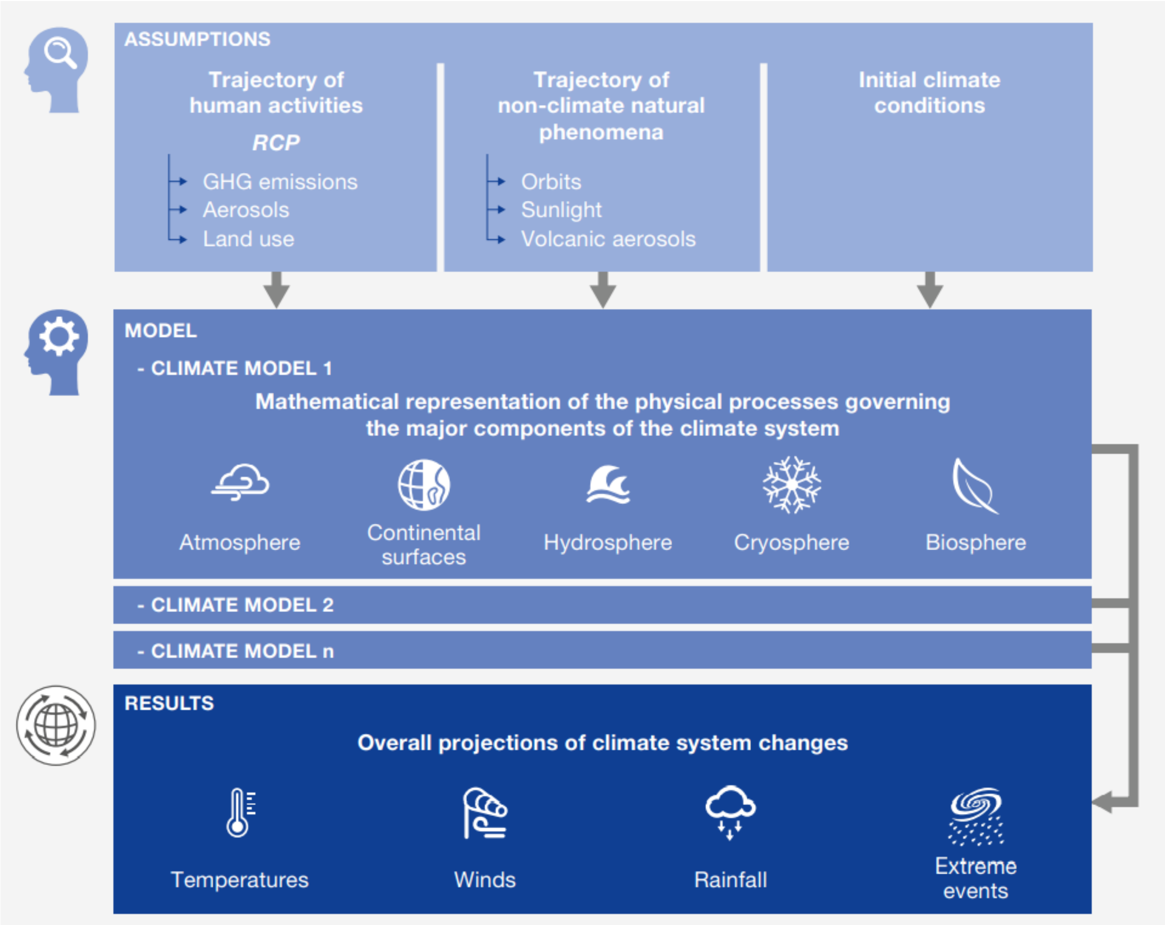


Figure 7: Construction process and components of a climate change scenario (I4CE, 2019).

Figures 8 and 9 shows the outcome of a using multiple GCM to project changes in surface temperature or average precipitation.

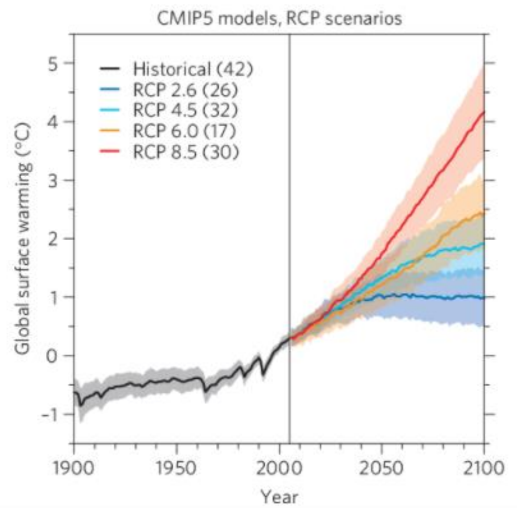


Figure 8: Global temperature change (mean and one standard deviation as shading) for the RCP scenarios run by CMIP5[17] . The number of models is given in brackets (Knutti and Sedlacek, 2013).

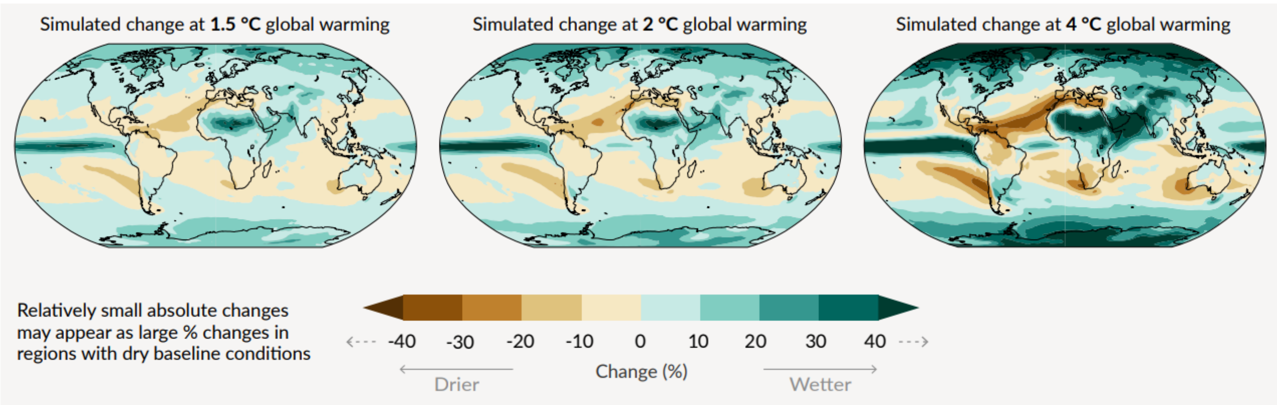


Figure 9: Annual mean precipitation change (%) relative to 1850-1900 run by CMIP6[18] (IPCC, 2021).

[17] GCM simulations are disseminated through different phases of coupled model intercomparison project (CMIP). The CMIP phase 3 (CMIP3) GCM simulations were used to prepare the fourth assessment report of IPCC (IPCC, 2007). The CMIP5 models were the improved version of CMIP3 models in terms of physical processes and network accuracy. CMIP5 was used to prepare the fifth assessment report of the IPCC (IPCC, 2013).

[18] A new coordinated series of climate experiments have recently been carried out under the umbrella of Phase 6 of CMIP. In many ways, the CMIP6 GCMs differ from previous generations, including finer spatial resolutions, enhanced parameters of the cloud microphysical process and additional Earth system processes and components such as biogeochemical cycles and ice sheets. The vital difference between CMIP5 and CMIP6 is the future scenario. CMIP5 projections are available on the basis of 2100 radiative forcing values for four GHG concentration pathways (van Vuuren, 2011). In contrast, CMIP6 uses socioeconomic pathways (SSPs) with the CMIP5 scenarios premises. Therefore, the shared SSPs are considered more realistic future scenarios (Song et al. 2021) .

Metrics for evaluation

The paper "Methodological principles of insurance stress testing - climate change component" (EIOPA, 2022) provides a list of indicators (for physical risk, transition risk or both) with the aim of providing a comprehensive picture of major risk drivers behind the impact of the chosen scenarios on certain areas.

In order to assess the impact of a scenario, depending on the type of risks that are evaluated (physical, transition or both), a set of indicators based on key figures are considered. The aim of those indicators is to provide a comprehensive picture of the major drivers behind the impact of the prescribed scenarios on balance sheet items, solvency or other variables.

Metrics are classified into Balance Sheet, Profitability, Technical and Direct. The list below, coming from the paper mentioned above, aims at summarizing the main ones.

Type of indicator	Indicator	Type of climate risk
Balance sheet	Solvency Capital Requirement	Physical and transition
	Excess of Asset over Liabilities (change of)	Physical and transition
	Asset over Liabilities (change of)	Physical and transition
	Stressed value or price change for each of the identified assets	Only transition
	Relative change of total technical provisions	Only physical
Profitability	Loss Ratio	Only physical
	Overall impact on the firm's profit and loss	Physical and transition
Technical	Gross/ceded/net aggregated losses	Only physical
	Main Exposures (Sum Assured)	Only physical
	Total assets subject to transitional risks	Only transition
	Annual Probability of occurrence	Only physical
Direct	GHG emissions of Investments	Only transition

3. CONCRETE EXAMPLES

MATERIALITY ASSESSMENT

Using the dummy non-life and life companies described in Annexes 1 and 2, the below examples show how materiality assessment could be performed for the asset side. Undertakings should consider their own portfolios when doing their analysis for their ORSA. The assessment below is an example of how an insurance group could reach a decision on the materiality and should not be used to draw the same conclusions.

The example first focuses on a qualitative analysis considering both physical and transitions risks for the assets. In a second step, to complement the qualitative analysis, more quantitative[19] analyses are performed.

It is important to consider that the different approaches described in this application guidance used for the non-life company could be also used for life company and vice versa.

QUALITATIVE ANALYSIS FOR THE ASSET SIDE

The qualitative analysis will provide a first insight into the materiality assessment. After the qualitative analysis, extended analysis will also be performed on specific parts of the asset side.

For the dummy non-life company

(i) Defining the business context

The investment portfolio primarily consists of corporate bonds. Other asset classes of the investment portfolio are government bonds, equities and deposits. The company prefers to keep the turnover of its underwriting low and offer the same insurance over short, medium and long-term. At the same time, the company is also interested to expand its property insurance coverage for natural catastrophes and is therefore interested to better understand for which type of coverages this would make sense also in the context of climate change.

(ii) Researching impacts of climate change on the business

[19] or more detailed analysis

Asset transition risk

Given that the dummy non-life company has a large exposure to corporate bonds, transition risk can result in a loss of market value and/or investment income within this asset class when borrowers/counterparties fail to properly address this risk. This risk can harm the dummy non-life company's investments in carbon-intensive sectors. It can materialize in terms of market risk, as these assets could be subject to a change in investors' perception of profitability. Transition risk can also result in writing-off mortgages and certain equities that are part of its investment assets and cannot make a transition to a low-carbon economy. In addition, the local offices have been recently renovated to a good energy efficient label, which makes them less vulnerable to transition risk in the short-term to medium term. The quantitative analysis below will provide further insights on the exposure of the dummy non-life to transition risks.

Asset physical risk

Given that the dummy non-life company has a large exposure to corporate bonds, depending on the sector, physical risks can result in a loss of market value and/or investment income within this asset class. The company foresees a negative pattern shift in floods for example. These events take the form of acute hazards, as these events are location dependent and produce immediate impacts. Chronic hazards that represent the slow and incremental impact of long-term changes (such as higher temperature) are not expected to have high materiality on the asset portfolio. Physical risk can also result in writing-off mortgages and certain equities that are affected by these events. The quantitative analysis will study further where the locations of the assets are and how it could be impacted by physical risks.

(iii) Assessing relevance to the business

In the third step the undertaking is assessing the materiality of each risk. From the physical risk perspective the company is of the opinion that on the asset side the acute risk is more likely to occur in the long term. Chronic risks are more likely to materialize in the long term on both sides of the balance sheet. However the expected exposure even on the long term is estimated to be very low for the company.

From the transition risk perspective the company expects the probability that policy changes happen in the short term as low. The company expects that the chance is more likely that policy changes take time before they are implemented. In the medium to long term the company expects the risk to be material. However the expected assets which would be impacted will be low. Further the company feels that if its current operations remain status quo it might face legal charges from investors and activist groups. Such actions will also affect its reputation.

Climate change risk		Time horizon (term)	Assets
Physical risk	Acute	Short	NM
		Medium	NM
		Long	M
	Chronic	Short	NM
		Medium	NM
		Long	NM
Transition risk	Policy	Short	NM
		Medium	NM
		Long	NM
	Legal	Short	NM
		Medium	M
		Long	NM
	Technology	Short	NM
		Medium	NM
		Long	NM
	Reputational	Short	NM
		Medium	M
		Long	M
	Market sentiment	Short	NM
		Medium	NM
		Long	NM

Table 3: Summary table for materiality assessment for the dummy non-life company.

*Note: *M stands for material, **NM stands for non-material.*

For the dummy life company

(i) Defining the business context

The assets of the dummy life company consists mainly of corporate bonds, equity and government bonds but also a commercial property where the headquarter has been established. The company's business focuses mainly on "with profit participation products" but also has a lower amounts of "term life insurance products" included in the "other liabilities" line of business. These assets are covering a portfolio of "with profit participation products", able to generate a return expected to fully cover the minimum guarantee embedded in the portfolio so the company does not plan to make significant changes to the Investments for the next years, neither in terms or investment mix nor in terms of duration which is around 10 years.

(ii) Researching impacts of climate change on the business

According to the Solvency II risk profile, the life company is exposed to market and mortality risk, particularly spread, interest rate and equity. Thus, it decides to focus the qualitative analysis on the most relevant asset classes and LoBs.

Equity prices might drop after a policy / technological / market shock. As a consequence, the ability of the dummy life company to meet its liabilities could be impaired. The exposure of the dummy life company is material.

Corporate bond prices might drop after a rating downgrade, which would depend on the carbon fuel exposure of the Investments. Holdings in financial institution might be indirectly affected by transition risk via the losses suffered by their investments. For the dummy life company the exposure is material.

Loans values might be affected when transition risk impacts negatively the credit worthiness of the counterparty or the amount of a collateral, which in turn affects the probability of default and the loss given default, if used in the computation of the loan value. For the dummy life company the exposure is not material.

The value of government bonds may also be affected by climate change risk, both in terms of physical and transition risk, although the impact is less direct than for equity and corporate bonds. Physical risk on government bonds would depend on the exposure of a country to physical risk events, also taking into account potential coverages against natural events that the jurisdiction might have in place. Countries might also experience different costs in the transition phase, depending on their degree of dependence on carbon-intensive activities and related indirect effect. EIOPA, in collaboration with climate economics modelers and scholars published the “Climate Risk Assessment of the Sovereign Bond portfolio of European insurers” where it emerges that the climate policy transition path chosen, and the role of fossil fuels and renewable energy technologies in the sovereign’s “Gross Value Added” and fiscal revenues, can affect the fiscal and financial risk position of a country (EIOPA, 2020). The life dummy company holds only European government bonds and does not plan to be, in the next 10 years, exposed towards government bonds in countries considered particularly vulnerable to climate risk. Thus, the exposure has been assessed as not material.

(iii) Assessing relevance to the business

From a transition risk perspective the company expects the probability that policy changes happen in the medium / long term as medium with a material impact on the holdings. Such actions will also affect its reputation. Technology risk is expected to have a similar impact for the same asset classes.

From a physical risk perspective, the company does not hold any liability exposure or relevant product which might cause a loss in case of negative event. The company considers physical risk not material, however it acknowledges that the physical risk might affect in different ways the solvency of the undertaking, for example by changes in the trends of mortality rates, and will keep monitoring it on a regular basis.

Climate change risk		Time horizon (term)	Assets
Physical risk	Acute	Short	NM
		Medium	NM
		Long	NM
	Chronic	Short	NM
		Medium	NM
		Long	NM
Transition risk	Policy	Short	NM
		Medium	M (mainly for corporate bonds and equity)
		Long	M (mainly for corporate bonds and equity)
	Legal	Short	NM
		Medium	NM
		Long	NM
	Technology	Short	NM
		Medium	M (mainly for corporate bonds and equity)
		Long	M (mainly for corporate bonds and equity)
	Reputational	Short	NM
		Medium	M (mainly for corporate bonds and equity)
		Long	M (mainly for corporate bonds and equity)
	Market sentiment	Short	NM
		Medium	NM
		Long	NM

Table 4: Summary table for materiality assessment for the dummy life company.

QUANTITATIVE ANALYSIS FOR THE ASSET SIDE

Different approaches are shown in each quantitative example below. Some approaches could be seen as complementary and depending on the data available to the undertakings some will work better than others.

Asset and transition risk: Corporate bonds and equities

The below analysis shows examples on how to conduct a materiality assessment for transitions risks on corporate bonds and equities. **The approaches are mentioned for illustrative purposes and other tools, methods might be available to do such analysis. Similar tools and methods can be used for both life and non-life undertakings.**

For the purpose of this application guidance, the dummy company will be used to explore two different approaches to a preliminary materiality assessment of the transition risk related to policy/technology risks (see section "Transition risk (policy and technology risks)").

The first approach involves the definition of a breakdown by sector of the investments, aimed at highlighting the assets held which might be exposed to transition risk via a reclassification of the list of assets via the NACE codes[20] in order to highlight potential vulnerabilities of the portfolio.

The second approach is based on the open-source tool PACTA[21] (Paris Agreement Capital Transition Assessment) which has already been used by some governments and supervisory authorities. The software developed by 2DII provides an analysis of the exposures by sector and technology based on mapping information on actual production sites to ultimate parent companies and thereby to the assets of the portfolio. In addition, it gives a comparison between the carbon intensity of the production plans of the Investments and various climate change scenarios.

	Input data	Tool/Method
Approach 1	NACE sector and investment value per ISIN	Mapping to Climate Policy Relevant Sectors
Approach 2	Investment value per ISIN	PACTA

[20] NACE codes are the "statistical classification of economic activities in the European Community"

[21] PACTA / Climate Scenario Analysis Program - 2DII (2degrees-investing.org)

In addition, this section also considers transition risks which might arise from litigation risks (see "Transition risk (litigation risks)").

Input data	Tool/Method
Investment value per ISIN	PACTA tool (not yet available)

For the dummy life company

Transition risk (policy/technology risks)

(i) Defining the business context

The starting point for the transition risk identification is a mapping of the list of investments in order to identify the dependency of the list of asset to the carbon-intensive sectors. The dummy life company holds a portfolio composed of corporate bonds and equities which could potentially be exposed to transition risk.

Therefore, the dummy life company counts on the following analysis in order to identify the vulnerabilities of the portfolio to climate change and plan immediate actions in order to mitigate it.

(ii) Researching impacts of climate change on the business

Approach 1: Overview by Sector

An example of application is the classification proposed by Battiston via the NACE codes, a parameter already included in the Quantitative Reporting Template S06.02 ("List of Assets"). The aim is to identify the sectors which might be relevant to climate mitigation policies (Climate Policy Relevant Sector - CPRS). It defines six climate-related sectors (agriculture, fossil fuel, utilities, energy-intensive, transport, housing) based on their greenhouse gas emissions, their role in the energy supply chain and the so-called carbon leakage risk classification. The table below (Battiston 2017) summarizes the mapping between the NACE codes and the sector considered climate sensitive.

CPRS sector	NACE codes
1-fossil-fuel	05, 06, 08.92, 09.10, 19, 35.2, 46.71, 47.3, 49.5
2-utility|electricity	35.11, 35.12, 35.13
3-energy-intensive	07.1, 07.29, 08.9, 08.93, 08.99, 10.2, 10.41, 10.62, 10.81, 10.86, 11.01, 11.02, 11.04, 11.06, 13, 14, 15, 16.29, 17.11, 17.12, 17.24, 20.12, 20.13, 20.14, 20.15, 20.16, 20.17, 20.2, 20.42, 20.53, 20.59, 20.6, 21, 22.1, 23.1, 23.2, 23.3, 23.4, 23.5, 23.7, 23.91, 24.1, 24.2, 24.31, 24.4, 24.51, 24.53, 25.4, 25.7, 25.94, 25.99, 26, 27, 28, 32
4-buildings	23.6, 41.1, 41.2, 43.3, 43.9, 55, 68, 71.1
5-transportation	29, 30, 33.15, 33.16, 33.17, 42.1, 45, 49.1, 49.2, 49.3, 49.4, 50, 51, 52, 53, 77.1, 77.35
6-agriculture	01, 02, 03

Table 5: Mapping of NACE codes and CPRS.

The table above is an example of a possible reclassification of the list of investment by the NACE codes, which would lead to the example of the representation below:

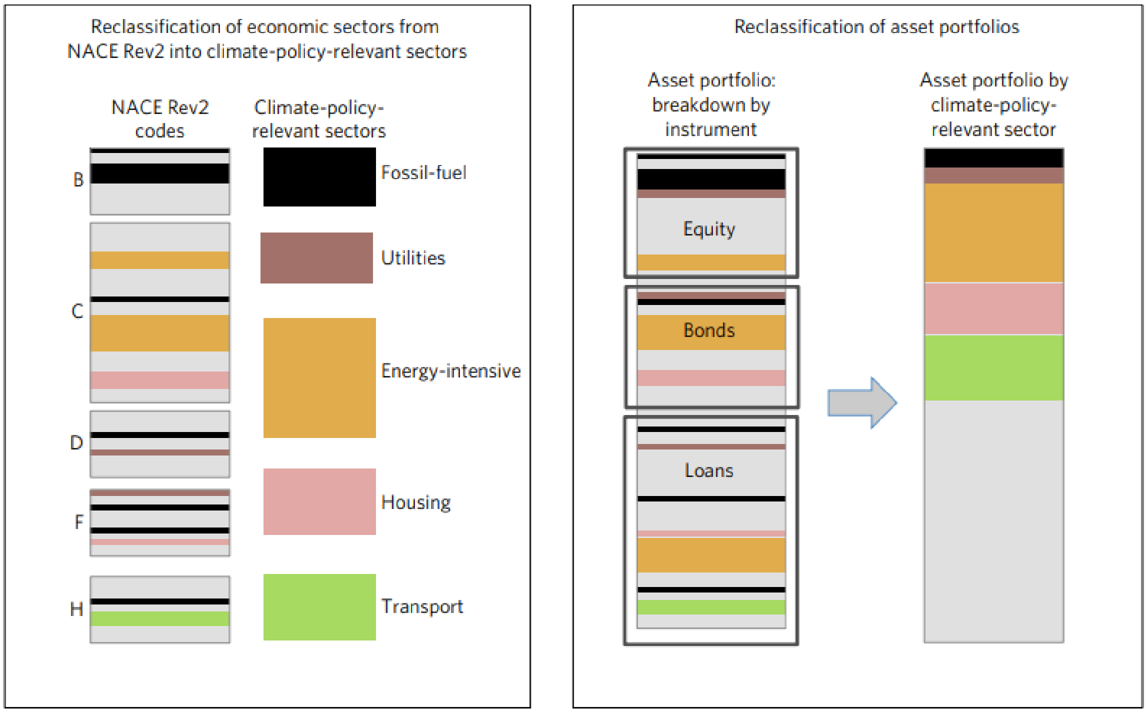


Figure 10: Reclassification of the investments via NACE codes[22].

After reclassifying the dummy company's assets with the mapping defined above, it is possible to obtain the breakdown by sector of both equity and corporate bonds. A look through should be applied when possible.

Corporate bonds not belonging to climate-related sectors are 45.5% of the sample. Out of the remaining 54.5% the directly climate-related sectors cover 23.6% (Utilities – Transport – Housing – Fossil Fuel).

Also the financial sector should be proportionally taken into account for the quantification of the transition risk due to its indirect exposure to transition risk borne by the assets of the issuer.

Sector	Amount	Weight
Finance	€ 20.3	30.7%
Fossil-fuel	€ 2.6	3.9%

[22] The names of the categories slightly differ from the updated "table 5" above because "Figure 10" refers to the original publication from 2017 of Battiston, the author of the paper mentioned in the introduction. Please note that the climate change reporting is constantly evolving and adjusting very quickly. For this reason, the most updated version of "Table 5 – Mapping of NACE codes and CPRS" should always be adopted when performing the assessment.

Housing	€ 2.4	3.6%
Excluded	€ 30.1	45.5%
Transport	€ 3.8	5.7%
Utilities	€ 6.9	10.4%
	€ 66.1	

Table 6: Corporate bonds portfolio reclassified by sectors (amounts) in million EUR.

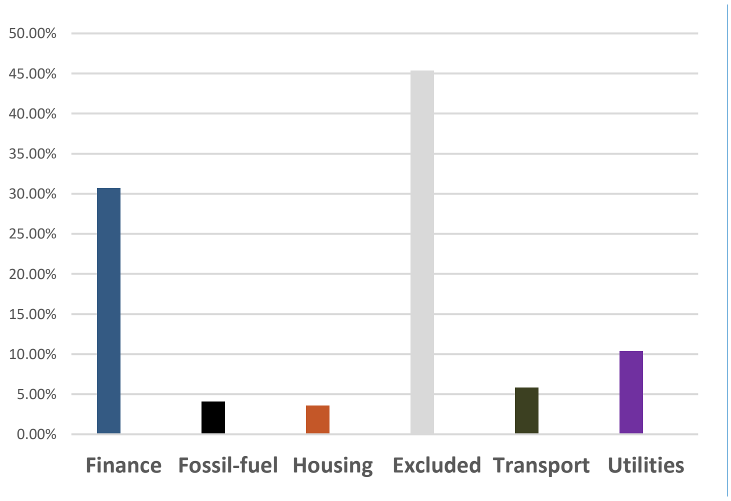


Figure 11: Corporate bonds portfolio reclassified by sectors (weights).

The exposure on equity shows that 59.5% of the exposure might be climate related, 20.7% of which holds direct exposure being related to fossil-fuel activities and 38.8% related to the financial sector, which potentially participates indirectly to transition risk.

Sector	Amount	Weight
Finance	€ 4.9	38.8%
Fossil-fuel	€ 2.6	20.7%
Excluded	€ 5.1	40.5%
	€ 12.7	

Table 7: Equity portfolio reclassified by sectors (amounts) in million EUR.

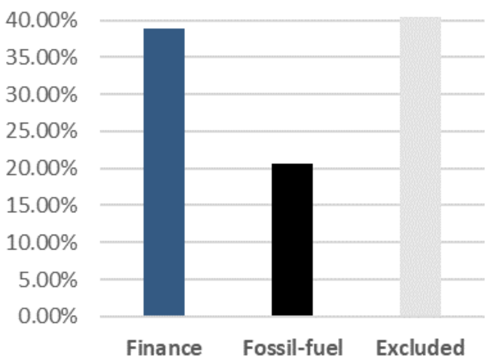


Figure 12: Equity portfolio reclassified by sectors (weights).

This exposure analysis is meant to be a starting point for developing ESG risk mitigation strategy and a tool to support management and investing decision, including a more granular analysis of the climate-related assets. If a material exposure to climate-related sectors is identified, the management is expected to set up a strategy in order to reduce it.

Despite being a relatively easy to implement approach for the identification of transition risk, it presents some limitations. It for example appears to be complicated to identify the source of energy used and its link with the GHG emissions (e.g. investments in renewable energies will be considered as climate related even if the level of emissions is very low). In order to complete the above analysis, undertakings might include additional elements not considered in the above approach and customize it according to their own risk profile, investment mix or perceptions of risks, e.g. the geographical component.

Approach 2: PACTA

The second approach concerns the use of the online tool PACTA, a climate scenario assessment for financial portfolio, which gives aggregated results by measuring the alignment of the portfolio to climate change scenarios.

The tool allows users to get a granular view of the alignment of their portfolios by sector and related technologies by sourcing sector-related data from Bloomberg or other financial data bases as well as company specific forward-looking production data from other providers (Asset Resolution or similar) and compare them with the technology roadmaps translated from the Paris agreement.

The inputs of the tool are easy to get and include ISIN[23], market value and currency for each security. They will be grouped into eight carbon intensive sector (oil and gas, coal mining, power generation, automotive, aviation, shipping, cement, and steel) considered to be responsible of more than 75% the overall total GHG emissions.

The uploaded portfolio will be audited and any invalid inputs notified by means of a downloadable audit report which includes the list of asset considered invalid.

In the example of the dummy company, almost all of the portfolio was covered by the PACTA database.

[23] ISIN stands for International Securities Identification Number, a 12-digit alphanumeric code that uniquely identifies a specific security.

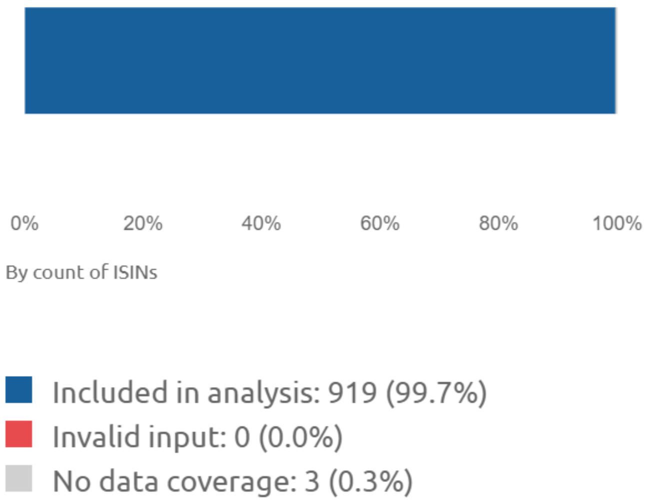


Figure 13: Assets covered by PACTA tools in the given example.

The PACTA reclassification for equity of the dummy life company leads to a calculated exposure of 21% in power, probably mostly related to the amount of equity invested in the Utilities sector highlighted in the Investment mix above.

PACTA also calculates current technology exposure of the portfolio and compares it against an index benchmark which can be selected from a list provided by 2DII (in this case S&P 500, selected as a mere example but the software offers some alternatives). The technology mix is based on asset level production data, mapping production sites to all companies in relevant sectors.

The graphs below relates to the dummy life company. The breakdown of the equity exposure by technology mix provides additional details over the technology and sustainability of the energy used. In the example, almost 80% of the equities under management refer to investments in low-carbon technologies which would partially compensate the risk entailed in the asset class considered. However, the transition risk exposure appears quite high with respect to all the benchmarks available.

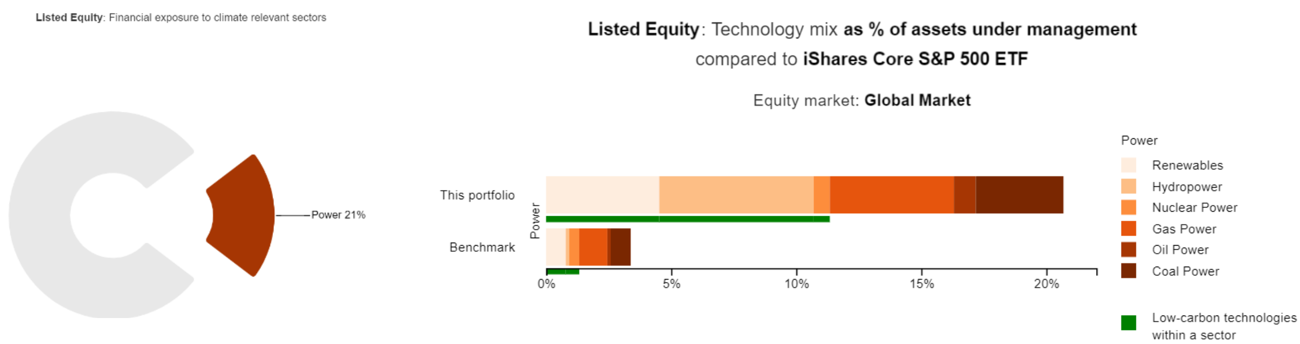


Figure 14: Equity – Exposures and Technology mix.

The corporate bond portfolio breakdown includes five of the eight carbon-intensive sectors included in the PACTA tool. Also in this case, for each of them the software shows a comparison with the benchmark and highlights the amount of low-carbon technologies within a sector.

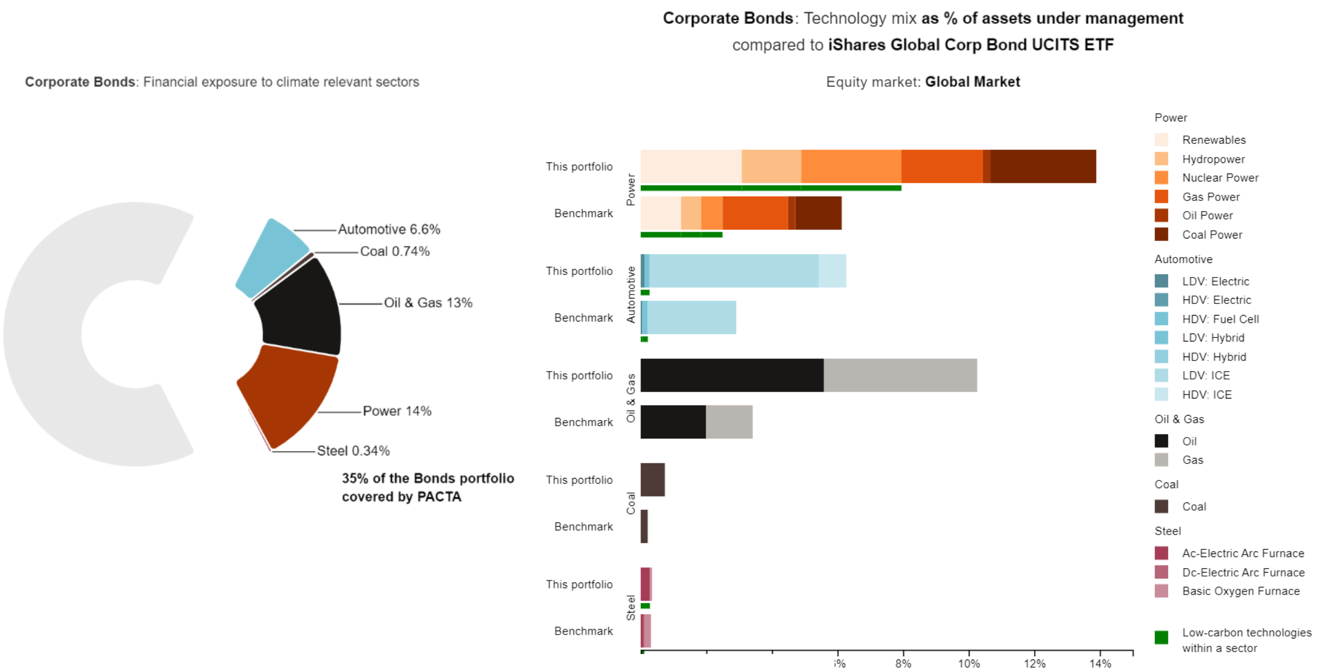


Figure 15: Corporate bonds – Exposures and Technology mix.

The tool allows a geographical representation of the carbon intensity of the equity and corporate bonds portfolio, by mapping the production of a specific technology to the respective country in a world map chart.

The dummy life company holds a relatively small equity portfolio with only four exposures, one of which operating intensively in the power industry in the Mediterranean region. As seen before, the only climate related sector for the holding is power and the dummy life company wants to have a clear view of the production of coal and oil Power, which still are part of the business of the equity investment.

The intensity of the grey color in the chart corresponds to the intensity of the coal power in the individual countries. In this case the equity investment operates mainly in Italy and Spain with little presence in Russia.

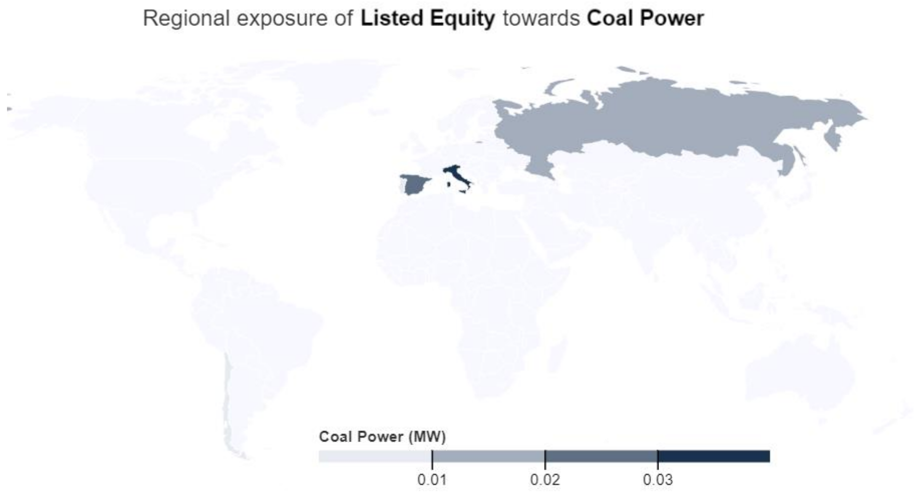


Figure 16: Equity – Coal - Regional exposure.

The corporate bonds portfolio is more diversified, both in terms of geographical exposure and energy source (precisely (automotive, coal, oil and gas, power, steel) because it counts a large number of securities very diversified as they arrive from the portfolio of five different undertakings. By keeping the example of the coal power it can be seen how this is reflected in the map below where the power production is high also overseas.

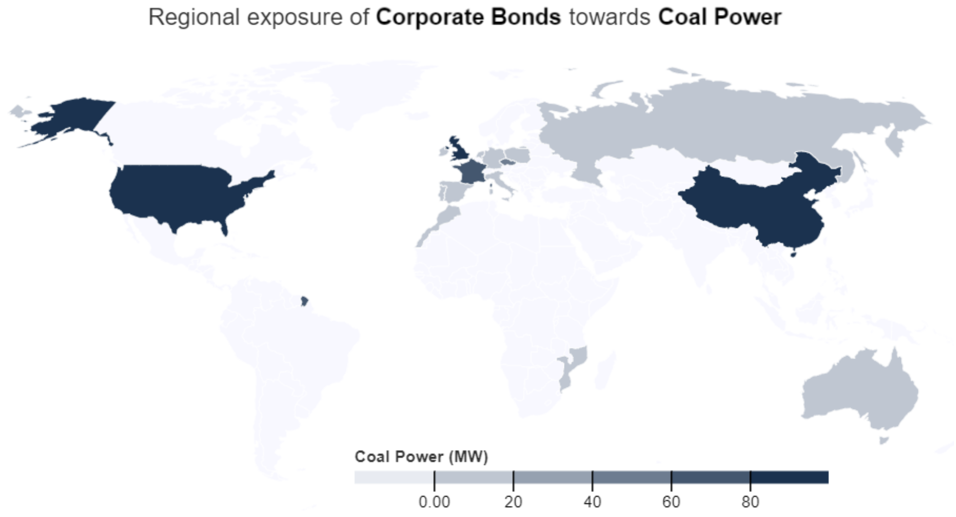


Figure 17: Corporate bonds – Coal - Regional exposure.

The same approach above can be applied to derive the exposure of the selected asset class towards a list of source of energy. As a further example, the two pictures below show the distribution of the oil power production on both equity and corporate bonds.

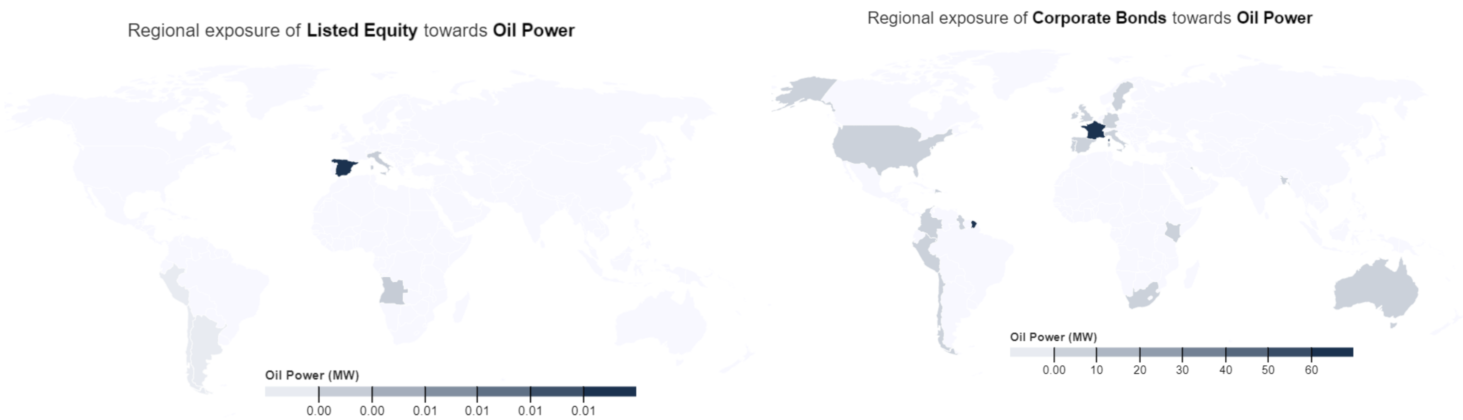


Figure 18: Equity and corporate bonds – Oil – regional exposure.

This initial analysis provides an example of a tool that can be used to analyze insurers' transition risks and can be used as a tool for future management actions and investment decisions, with the objective of reducing and mitigating it.

(iii) <u>Assessing relevance to the business</u>

The two different approaches presented above, despite presenting slightly different results, consider transition risk material.

The equity portfolio has a low diversification with only one equity instrument potentially exposed to transition risk. Despite presenting a proper level of diversification, the corporate bonds portfolio appears to be materially exposed to transition risk. Hence, the dummy life company considers appropriate to perform a scenario analysis.

Climate change risk	Asset	Time horizon (term)	Materiality (M/NM*)
Transition Risk	Corporate bonds	Short	M
		Medium	M
		Long	M
	Equity	Short	NM
		Medium	M
		Long	M

Table 8: Summary table for Transition risk materiality assessment.

Transition risk (litigation risk)

(i) Defining the business context

The example below aims at providing an overview of an approach, aiming at assessing the litigation risk, developed by 2DII and based on the Social Cost of Carbon. The underlying rationale is a higher cost to be borne by companies which relies on carbon intensive power sources due to the potential future litigation claims coming from it.

The potential future litigation is expected to come from equity and corporate bonds, whose assessment will be the basis for the risk assessment. For the definition of the business context, the same considerations detailed in the above section on transition risk (policy/technology) are valid and will be used as a preliminary analysis for litigation risk.

(ii) Researching impacts of climate change on the business

That approach measures the delta of a company's CO2 emissions against a scenario benchmark and prices each excess ton of CO2 that the company is projected to produce until the litigation event with the social cost of carbon. After the litigation event, the company is assumed to stay in line with the targets of the benchmark, so that no further litigation risk accumulates. Therefore, the higher the intensity of CO2 generated by the Investments, the higher the litigation risk associated to the portfolio.

The carbon delta associated with each equity and bond holding in the portfolio can be derived from the PACTA analysis of said portfolio. The following analysis is included as part of the scenario analysis but will be introduced now in order to perform the materiality assessment for litigation risk. The information below does not relate directly to the emissions amounts but it is reasonable to assume that the higher the amount of gas, coal and oil used the higher the amount of emissions.

The dummy life company performed the PACTA scenario analysis on equity and corporate bonds and the results are shown in the charts at the left.

Equity: For gas and coal power the expected amount of power used is aligned with the 1.5 degrees target of the Paris agreement (SDS scenario). On the other hand, the production of oil appears higher than the targets. The overall exposure of the three sources is assumed to be compensated and therefore not material for equity.

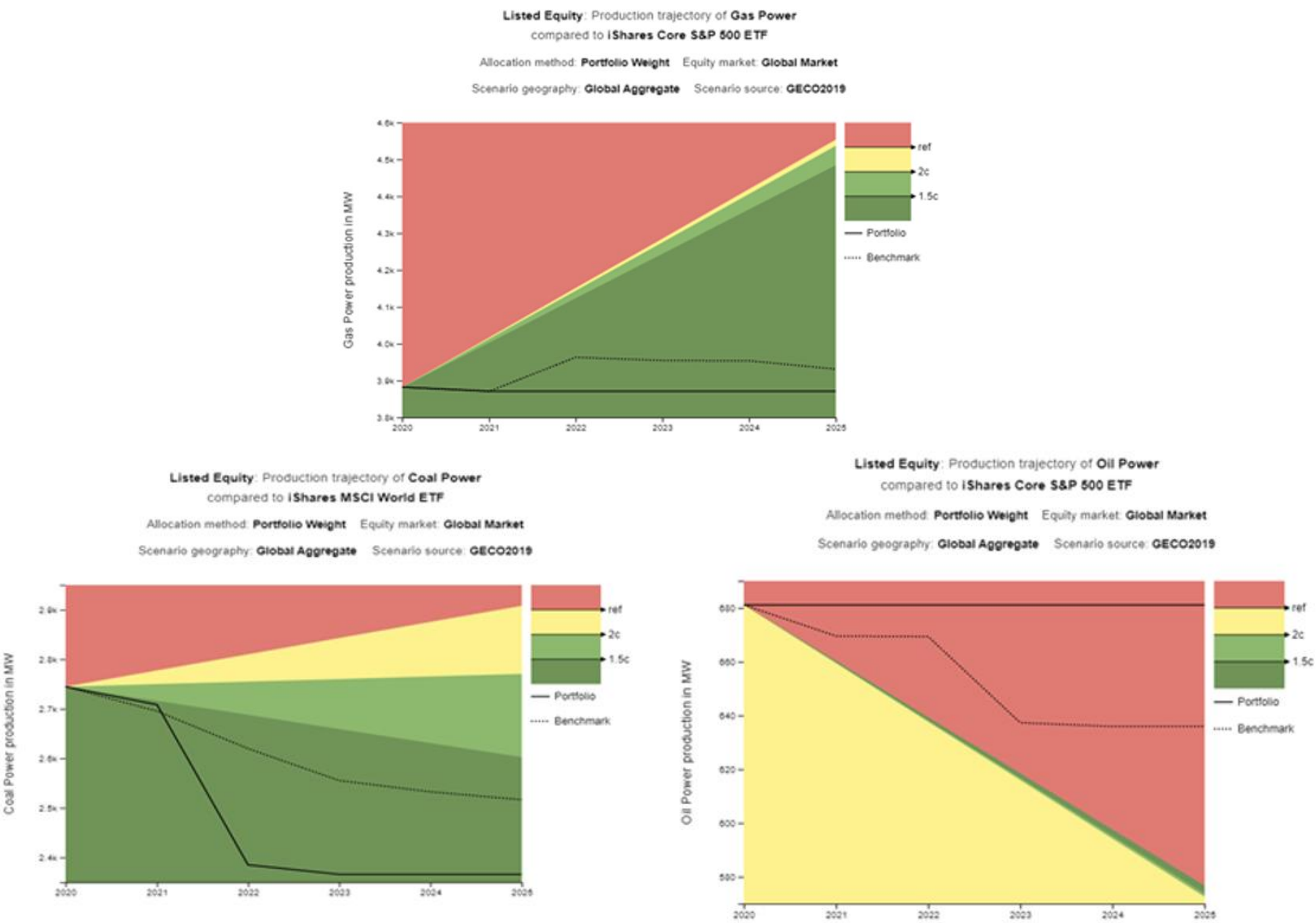


Figure 19: Equities - production trajectory.

Corporate bonds: The corporate bonds portfolio shows a higher expected production of carbon-intensive power.

Coal power's trajectory shows a positive pathways, while gas and oil picture a higher amount of power production. According to the power consumption the exposure in corporate bonds might be material.

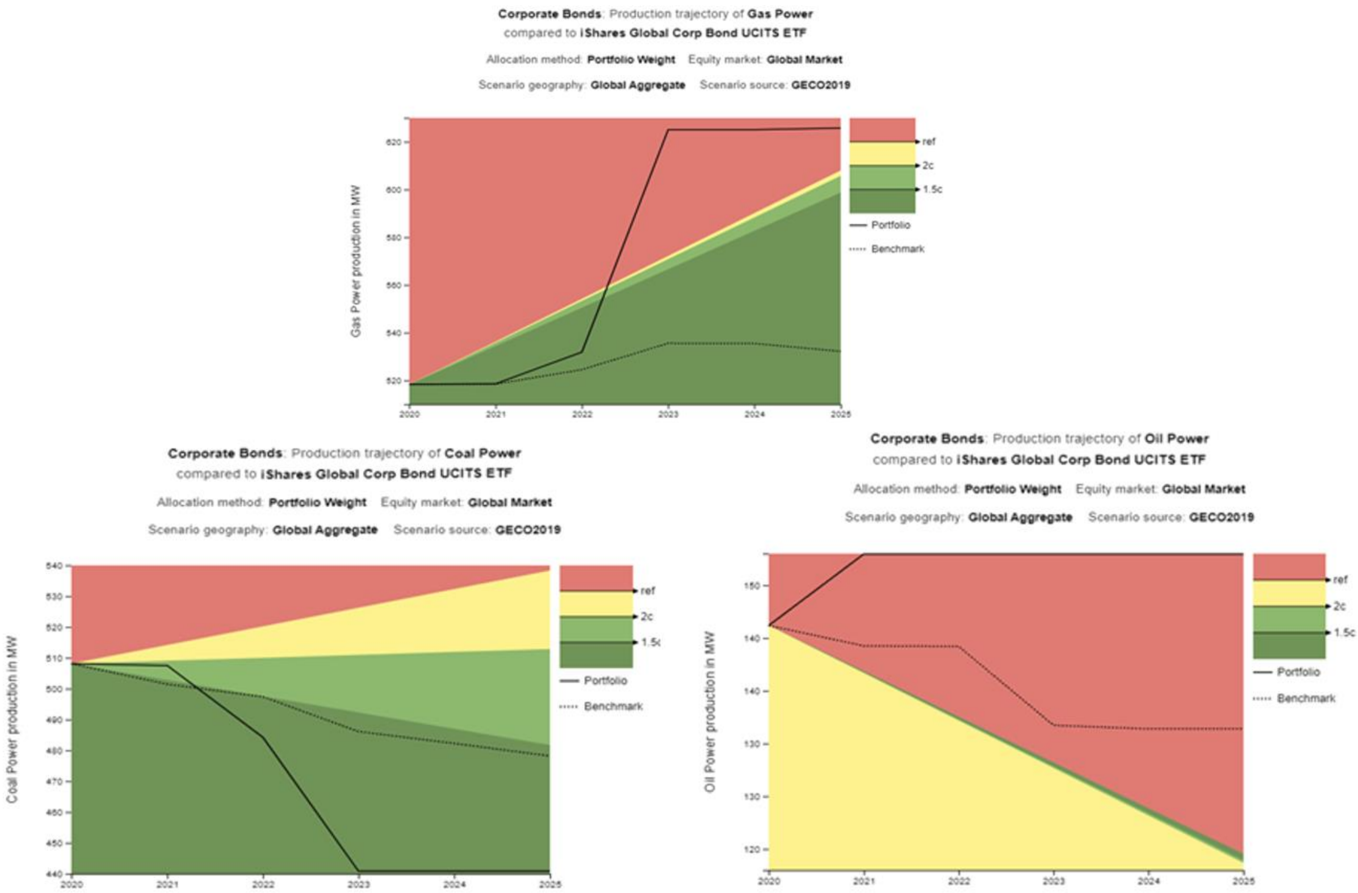


Figure 20: Corporate bonds - production trajectory.

For companies that are aligned with their targets, the carbon delta will be <= 0 so that they are not at risk of building up litigation costs. For companies that are misaligned with their emissions targets, a positive carbon delta will result in litigation costs to be paid in the year of the litigation event and this might have an impact on the corresponding Assets. Thus, the scenario analysis recalled above could be used to assess the materiality of litigation risk in the undertaking portfolios. Under this approach, if the forward-looking projections of the portfolio are aligned with the Paris Agreement Targets the impact of litigation risk is considered not material.

(iii) <u>Assessing relevance to the business</u>

On the equity side, the company compensate the misalignment on the oil sector with a positive results of coal and gas. For corporate bonds, coal shows a positive alignment while gas and oil highlights a higher usage of carbon with respect to the given benchmark (Paris agreement).

The dummy life company considers the exposure to litigation risk currently not material due to the low level of the oil exposure with respect to its investments, but acknowledges that the forward-looking developments of the production pathways associated to its list of investments might worsen in the next years and aim to stay within a carbon budget as defined by the Paris agreement (transformed into production pathways by a climate model). Thus, the company intends to reduce and mitigate its investments in the oil sector in order to converge towards a more aligned portfolio that would reduce the risk of climate claims and, in the same time, reduce the policy and technological risk drivers of transition risk.

Climate change risk	Asset	Time horizon (term)	Materiality (M/NM*)
Litigation Risk	Corporate bonds	Short	NM
		Medium	NM
		Long	NM
	Equity	Short	NM
		Medium	NM
		Long	NM

Table 9: Summary materiality assessment.

For the dummy non-life company

(i) Defining the business context

Following the same rationale used for the dummy life company, also the dummy non life company holds a portfolio composed of corporate bonds and equities which could potentially be exposed to transition risk..

(ii) Researching impacts of climate change on the business

The same approach used for the dummy life company can be made for the dummy non-life company. Please refer to the section "*Asset and transition risk: Corporate bonds and equities - Transition risk (policy/technology risks) - Approach 1: Overview by Sector*" for further details.

(iii) Assessing relevance to the business

The approach chosen by the dummy non-life company is the reclassification by sector using the information in-house. After the reclassification, this is the result:

Corporate bonds

Corporate bonds amounts to 34% of the total investments and 17.8% of the total assets, of which 10.4% are attributable to Utilities and 4.1% to fossil-fuel. The indirect exposure in the financial sector is 20%.

Sector	Amount	Weight
Finance	€ 2.3	20.1%
Fossil-fuel	€ 0.5	4.1%
Excluded	€ 7.4	65.4%
Utilities	€ 1.2	10.4%
	€ 11.4	

Table 10: Corporate bonds portfolio reclassified by sectors (amounts) in million EUR.

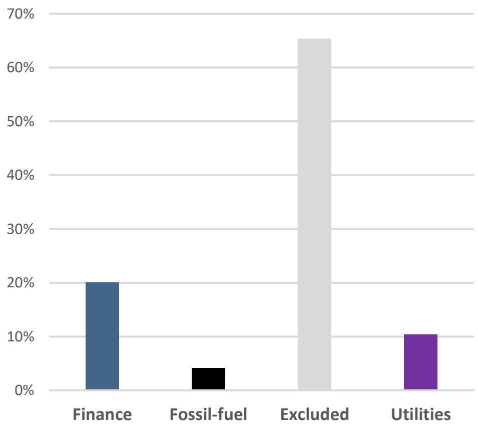


Figure 21: Corporate bonds portfolio reclassified by sectors (amounts) in million EUR.

Equity

Equity amounts to 38% of the Total Investments and 20.3% of the total assets, of which 7.4% are attributable to Utilities and 4.6% to Housing. The indirect exposure in the financial sector is 12.1%.

Sector	Amount	Weight
Finance	€ 1.6	12.1%
Housing	€ 0.6	4.6%
Excluded	€ 9.9	75.9%
Utilities	€ 0.9	7.4%
	€ 13.0	

Table 11: Equity portfolio reclassified by sectors (amounts) in million EUR.

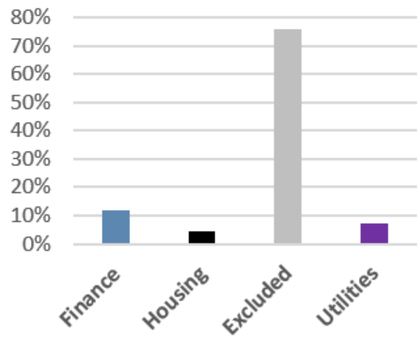


Figure 22: Equity portfolio reclassified by sectors (amounts) in million EUR.

Given the relatively low weight of the corporate bonds and equity to the investments and assets its climate exposure has been considered of negligible materiality but worth monitoring over time.

Asset and physical risks: Government bonds

Governments are exposed to both transition and physical risk and this is expected to worsen in the next years. This might lead to a higher government spending but also higher government bonds yields. Many countries are developing plans in order to reduce the carbon emissions in order to improve their readiness and lower their vulnerability, but there is uncertainty on how the impact of climate change will distribute among the countries.

Countries present a different tolerance to an increase of temperature, but also different frequencies of environmental catastrophic events. It is likely that the conversion to renewable energies will harm the economies which rely on the trading of carbon-intensive utilities. There are several studies based on environmental factors which aim at assessing the degree of resilience and vulnerability to both physical and transition risk and that might give an idea of the potential long-term impact.

The below analysis shows an example on how to conduct a materiality assessment for physical risks on government bonds. Similar tools and methods can be used for both life and non-life undertakings. While it might be complicated to quantify precisely the physical risk associated to each government-issued security, a geographical assessment of the government bonds portfolio might be a first step for the identification of the potential risk.

Input data	Tool/Method
Localization of government bond exposure	ND-GAIN Country Index Peseta IV

For the dummy life company

(i) <u>Defining the business context</u>

The dummy life company performs the breakdown of the government bonds portfolio which led to the following pictures, where the countries corresponds to the main markets were the ones where the company operates. The weight of the government bonds is 21.2% of the total Investment.

Country of Exposure	Weight
PORTUGAL	32%
GERMANY	19%
FRANCE	16%
SWEDEN	13%

The potential impact of a low carbon transition on insurers portfolios of sovereign bonds is moderate in terms of its magnitude. However, it is non-negligible in several feasible scenarios (EIOPA, 2019). The current analysis leverages on existing studies on the impact of physical risk on government bonds in order to assess the actual materiality of an insurer's government bonds portfolio.

(ii) Researching impacts of climate change on the business

The chart below refers to the output of a study aiming at estimating how an increase in temperature would affect the GDP which, in turn, might have an impact on the pricing of the government bonds.

Figure 25 from the PESETA IV shows that the impact of climate change in the economies of the countries might be relevant and, above all, very different depending on how the economies will be able to prevent it and face it. However, the study does not aim to give an estimate of the reduction of prices due to the pictured reduction in GDP.

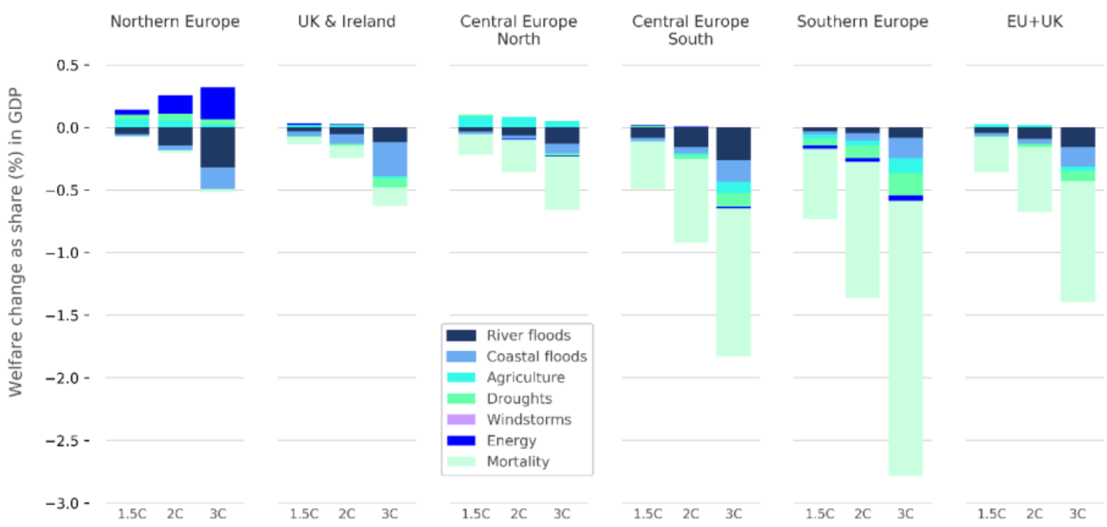


Figure 23: Welfare loss (% of GDP) from considered climate impacts excluding human mortality (JRC, 2020).

Despite the internal differences shown in the chart above, European Countries are expected to be less impacted by physical risk than other countries around the world. The Notre Dame index (ND-GAIN country index)[24] is an attempt to measure the degree of vulnerability, i.e. its "degree of sensitivity and ability to adapt" to physical risk and might be used to assess, together with the

[24] Country Index // Notre Dame Global Adaptation Initiative // University of Notre Dame

location of the investments, the materiality of physical risk to the government bonds portfolio. A publication of IAIS (2021)[25] describes how the index can help governments, businesses and communities to better prioritise investments for a more efficient response to the immediate global challenges ahead.

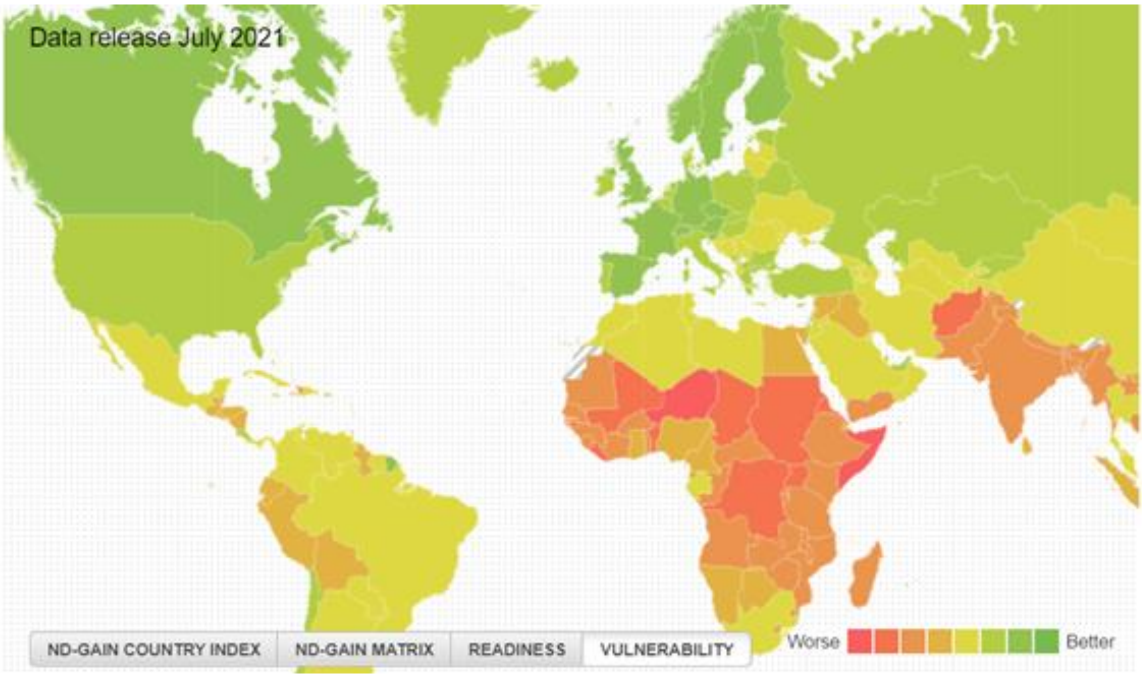


Figure 24: ND Index – Countries by vulnerability.

(iii) <u>Assessing relevance to the business</u>

The dummy life company checked the exposure against the Notre Dame index. After analysis of the overall weight of the portfolio of government bonds and its geographical breakdown, the impact of physical risk for government bonds has been considered not material. However, the company is conscious that the evolving situation might differ year by year and will monitor the evolution of the selected indexes with regular frequency.

Climate change risk	Time horizon (term)	Asset
Acute	Short	NM
	Medium	NM
	Long	NM

[25] Gimar special edition: The impact of climate change on the financial stability of the insurance sector

Physical risk	Chronic	Short	NM
		Medium	NM
		Long	NM

Table 12: Materiality assessment Government bonds.

For the dummy non-life company

The investment mix of the dummy non-life company shows a low amount of government bonds (5.9% of total investment and 3.1% of total assets) and aims at reaching a higher return via equity and corporate bonds. The exposure has been considered not material.

Asset and physical risks: Corporate bonds

The below analysis shows examples on how to conduct a materiality assessment for physical risks on corporate bonds and equities. Corporates may, for example, be impacted by physical risks through the destruction of physical capital, but also through the disruption of production and supply chains, adaptation costs or deteriorations in macroeconomic conditions (IPCC, 2014).

As mentioned before the approaches are mentioned for illustrative purposes and other tools, methods might be available to do such analysis. Similar tools and methods can be used for both life and non-life undertakings.

Input data	Tool/Method
Localization of corporate bonds and equity investments	Physical risk tool from 2DII

For the dummy life company

(i) Defining the business context

Assessing financial system exposures of the undertaking to physical risk drivers requires information on the geo-spatial characteristics of undertaking's exposures (ECB/ESRB, 2021a). The current analysis is based on a comparison of asset-location in PACTA sectors with maps that indicate the local climate parameters or a relative change of climate parameters compared to a reference period under a given scenario.

The investments are made typically for the next 10 years. However the dummy life company has a tradition to not have a very volatile investment portfolio and it is therefore expected to have a similar composition for the next 20 years (long time horizon).

The below analysis considers the following sectors: Oil&Gas extraction, power, coal, car production (as the method is linked with PACTA sectors). Ideally the undertakings should consider all sectors. Each ISIN is traced down to asset-level data. Most of the assets for the dummy life company are located in France, Spain, Italy, Portugal and USA. Figure 27 shows an example of the geo-localisation distribution of the production assets (for corporate bonds) for Portugal.

Figure 25: Geographical distribution of the assets in Portugal for the dummy life company.

(ii) <u>Researching impacts of climate change on the business</u>

In order to research the impact of climate change on the portfolio, following risk maps are considered:

- Climate impact explorer (http://climate-impact-explorer.climateanalytics.org/impacts/): focus on relative change of climate parameters on different parameters compared to a reference scenario.

- Climate Data Factory (https://theclimatedatafactory.com/) focus on absolute risk levels.

For example, the NGFS climate impact explorer shows changes in precipitation between 2030 and 2050. Changes in precipitation could indicate changes in flood risks for example.

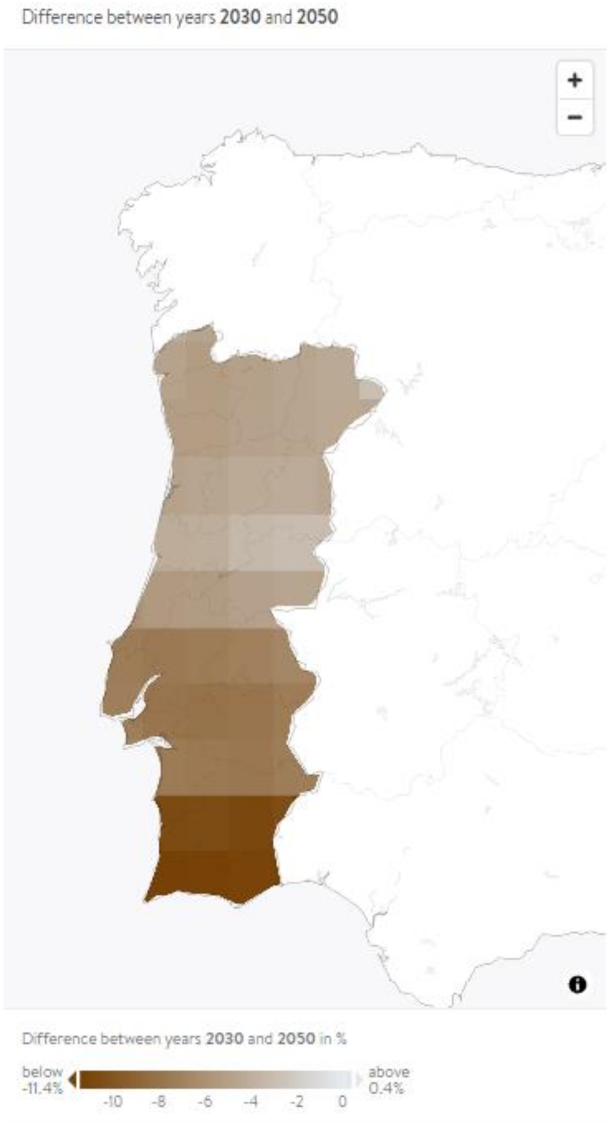


Figure 26: Difference in precipitation in % between 2030 and 2050[26].

Combining the above mentioned risk maps (for example the changes in precipitation[27]), the geo-localized assets are used to understand which assets would be impacted by climate change (in our example changes in precipitations due to climate change).

[26] Climate Analytics — Climate impact explorer

[27] Other metrics are available such as changes in temperature, changes in wind speeds…

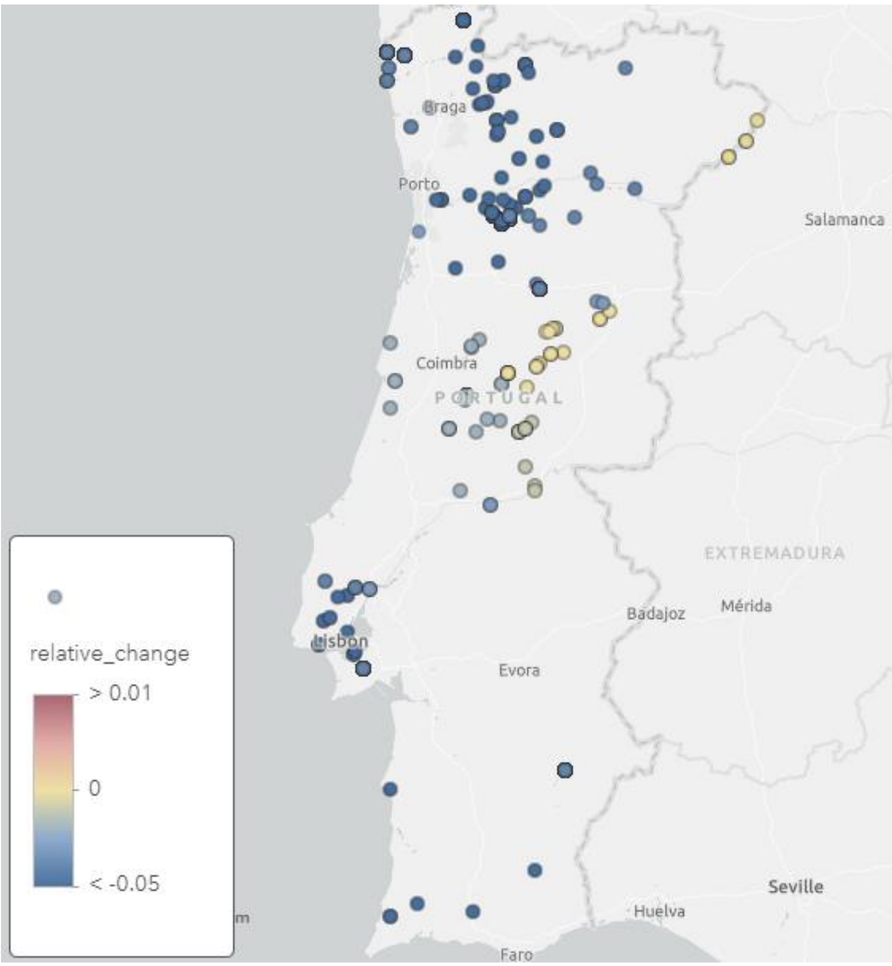


Figure 27: Changes in precipitation which will impact the different assets (from corporate bonds portfolio).

Additional analysis could also be used to understand the possible impact of climate change on the current investment portfolio on mid and long term time horizons. The table below for example shows the share of undertakings (in %) in areas of high or increasing exposure to a physical hazard (such as hurricanes, sea level rise, floods, water stress, heat stress and wildfire).

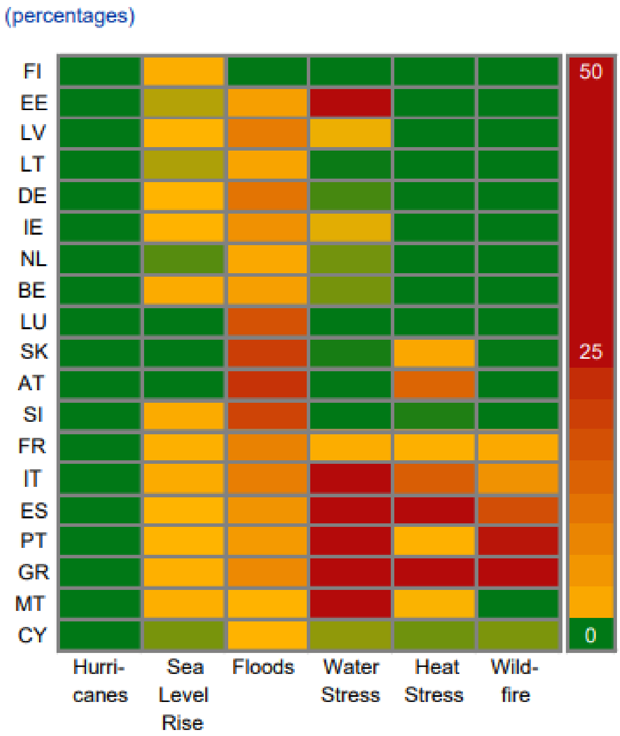


Figure 28: Share of undertakings (in %) in areas of high or increasing exposure to a physical hazard Source: Four Twenty Seven, an affiliate of Moody's, and ECB calculations (ECB/ESRB, 2021a).

A more granular analysis could be done using for example information shown in Annex 1 "Exposure level to individual physical hazards for 1.5 million firms in Europe".

(iii) <u>Assessing relevance to the business</u>

To assess the materiality, climate change and of course the size of the exposed value should be taken into consideration.

The analysis above shown for Portugal indicates that the changes in precipitation due to climate change will be rather negative changes (i.e. less precipitation). This could indicate that the flood risk in Portugal could decrease. However, flood risk will also be impacted by additional parameters such as sea level rise for example. Using also additional information from the ECB/ESRB study (2021a), it was concluded that flood risk could have a medium impact as well as wildfire for Portugal. A number of additional perils could be considered such as water stress for example. To assess the exposed value, the part of the corporate bond investment in Portugal was considered for the below table. However, it should be noted that not all investments will have the same financial damage as it will depend how strongly they will be impacted by climate change. All countries considered in the corporate bond portfolio should be analyzed for different relevant perils.

Country	Peril	Investment value impacted by climate change (in Million)	Climate change impact and probability on dummy exposure	Materiality assessment for the dummy non-life company
Portugal	Flood	2	medium/medium	No, exposed value is small
Portugal	Wildfire	2	high/high	No, exposed value is small
Portugal	Water Stress	2	high/high	No, exposed value is small
…	…	…	…	…

Table 13: Analysis per peril/region.

The corporate bond portfolio could be impacted by a number of different perils and it is not straight forward to understand if the portfolio is impacted what could be the consequent damages on the valuation for example. Due to the relevance of the corporate bond portfolio for the dummy life company, we could expected that some perils might have a material impact but rather on the long term.

<table>
<tr><th colspan="2">Climate change risk</th><th>Time horizon (term)</th><th>Assets</th></tr>
<tr><td rowspan="6">Physical risk</td><td rowspan="3">Acute</td><td>Short</td><td>NM</td></tr>
<tr><td>Medium</td><td>NM</td></tr>
<tr><td>Long</td><td>M</td></tr>
<tr><td rowspan="3">Chronic</td><td>Short</td><td>NM</td></tr>
<tr><td>Medium</td><td>NM</td></tr>
<tr><td>Long</td><td>M</td></tr>
</table>

Table 14: Summary of the materiality assessment for the physical risks and corporate bonds and equities.

For the dummy non-life company

(i) Defining the business context

As mentioned above, assessing financial system exposures to physical risk drivers requires information on the geo-spatial characteristics of undertaking's exposures. Most of the firms into which the dummy non-life company has invested are localized in Germany, Luxembourg, Austria and Latvia.

The investments are made typically for the next 5 years (medium time horizon). However the dummy non-life company has a tradition to not have a very volatile investment portfolio and it is therefore expected to have a similar composition for the next 10-15 years (long time horizon**).**

(iii) <u>Assessing relevance to the business</u>

Similarly as done for the dummy life company, the next step involves combining the geo-spatial characteristics of financial institutions' exposures with data on physical risk drivers. Based on the relative low importance of the corporate bond portfolio for the dummy non-life and the fact the impacts from climate change are expected to be low on the valuation of the assets, the risk is estimated to not be material.

Asset and physical risks: Property investments

The below analysis shows examples on how to conduct a materiality assessment for physical risks on property investments. Similar tools and methods can be used for both life and non-life undertakings.

Input data	Tool/Method
Localization of property investment	EEA climate data

For the dummy non-life company

The property investment of the dummy portfolio value for property own use is equal to 10 million EUR and the average value for property for (other than for own use) is equal to 0.5 million EUR.

(i) <u>Defining the business context</u>

The properties are mainly localized in five different countries (see Figure 31). A proper assessment of climate change impact for the property will need to be made considering a short, mid and long time horizon as the dummy non life company has recently invested in renovating most of them.

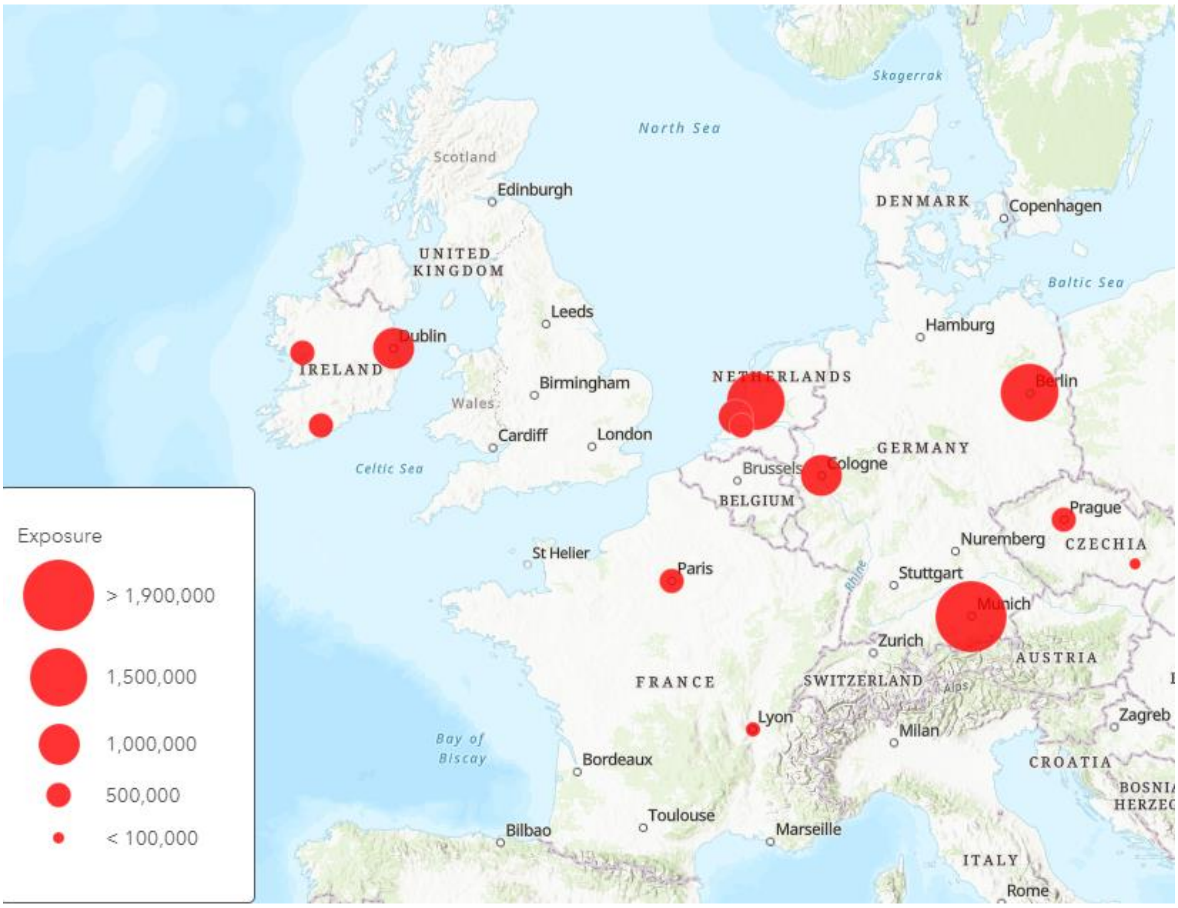


Figure 29: Localization of the property investments (in EUR).

(ii) Researching impacts of climate change on the business

Now that the exposure's location is known, the specific exposure can be related to climate change risks. Climate change impacts will vary significantly between different types of perils as for different geographical locations.

Wildfire

For example, if it is possible to map the properties location and values with wildfire danger using the EEA discover map services[28] (see Figure 32). From these maps it can for example be seen that the properties investments are located in areas which might have a relative small wildfire risk.

[28] EEA - Services Monitoring (europa.eu)

Wildfire is currently not considered in the standard formula but could still be a risk which is relevant for undertaking's to be aware of.

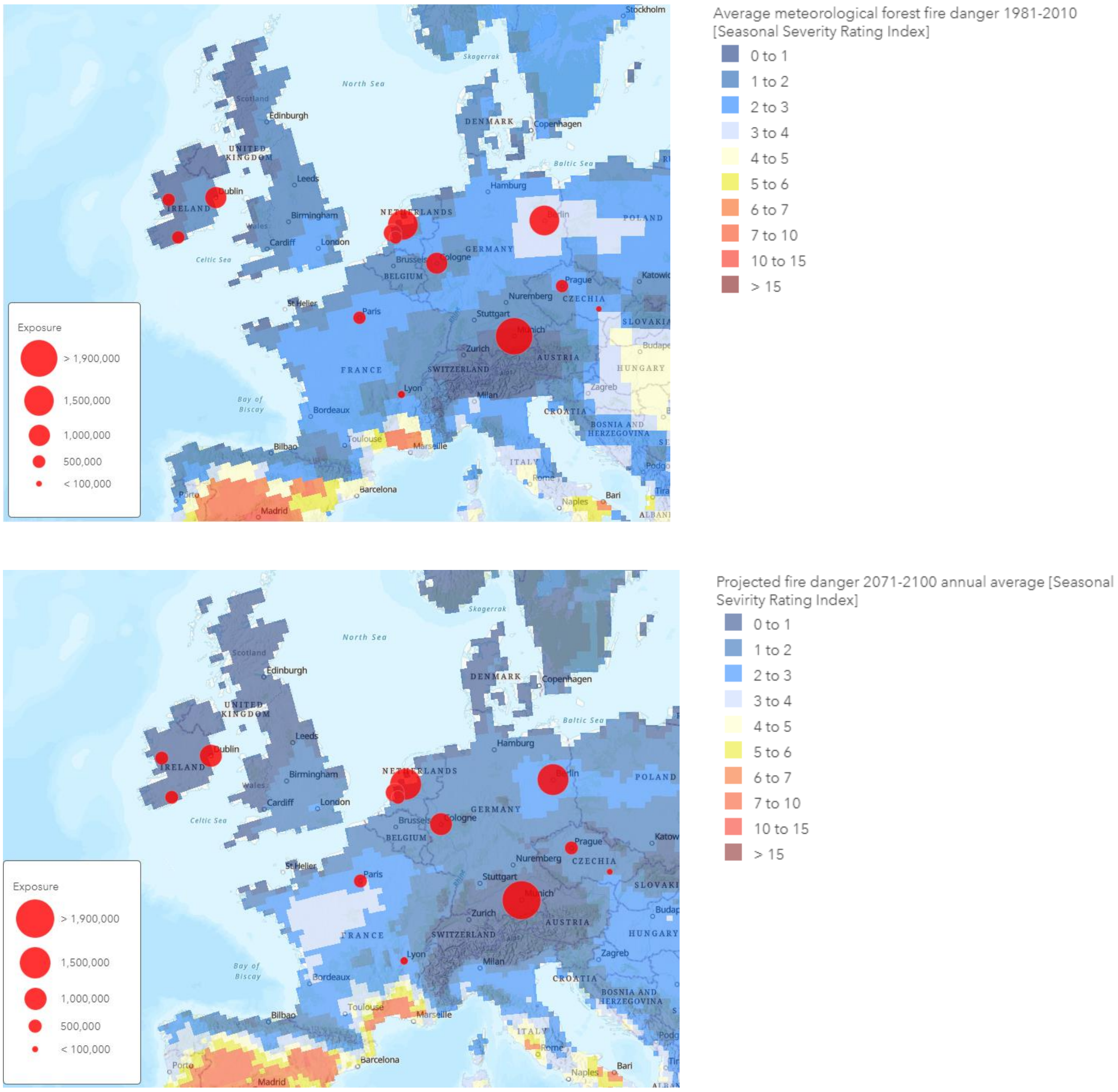


Figure 30: Mapping of fire danger. Source: EEA[29].

<u>Coastal floods</u>

The Netherlands, Germany, Ireland and France will be impacted by higher floods and this at short, medium and long time horizons. The EEA discover map services also provides maps on coastal floods

[29] ArcGIS - My Map

for example (see Figure 33). Properties located in the Netherlands will also be impacted by coastal flooding due to sea level rise. This will take place on a long time horizon.

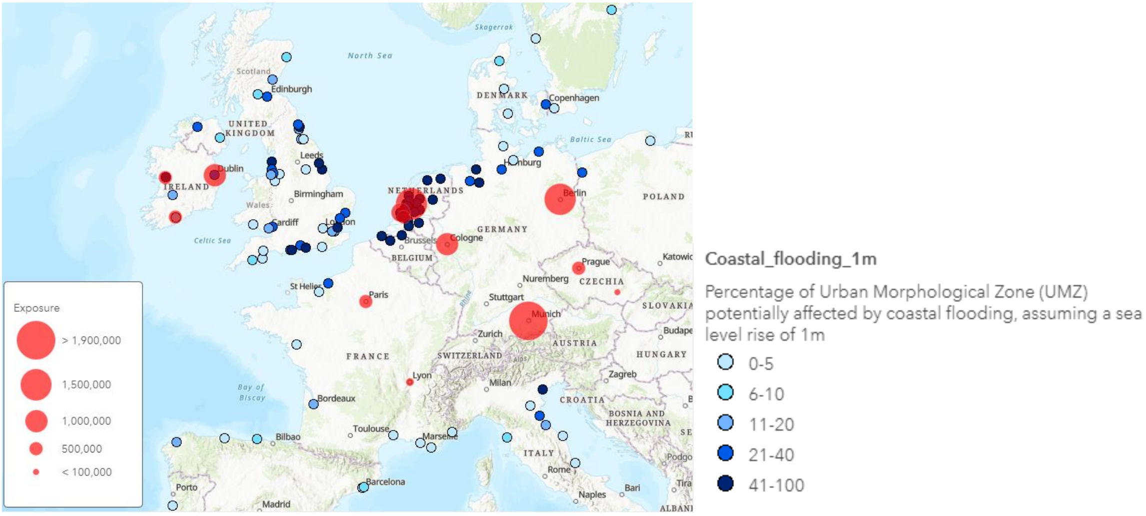


Figure 31: Percentage of Urban Morphological Zone potentially affected by coastal flooding, assuming a sea level rise of 1m. Source: EEA[30].

<u>River/flash/pluvial flood</u>

Heavy precipitation events are likely to become more frequent in most parts of Europe. The projected changes are strongest in Scandinavia and northern Europe in winter. Figure 34 presents the projected changes in annual precipitation (in %) from 2021-2050 and 2071–2100.

[30] EEA - Services Monitoring (europa.eu)

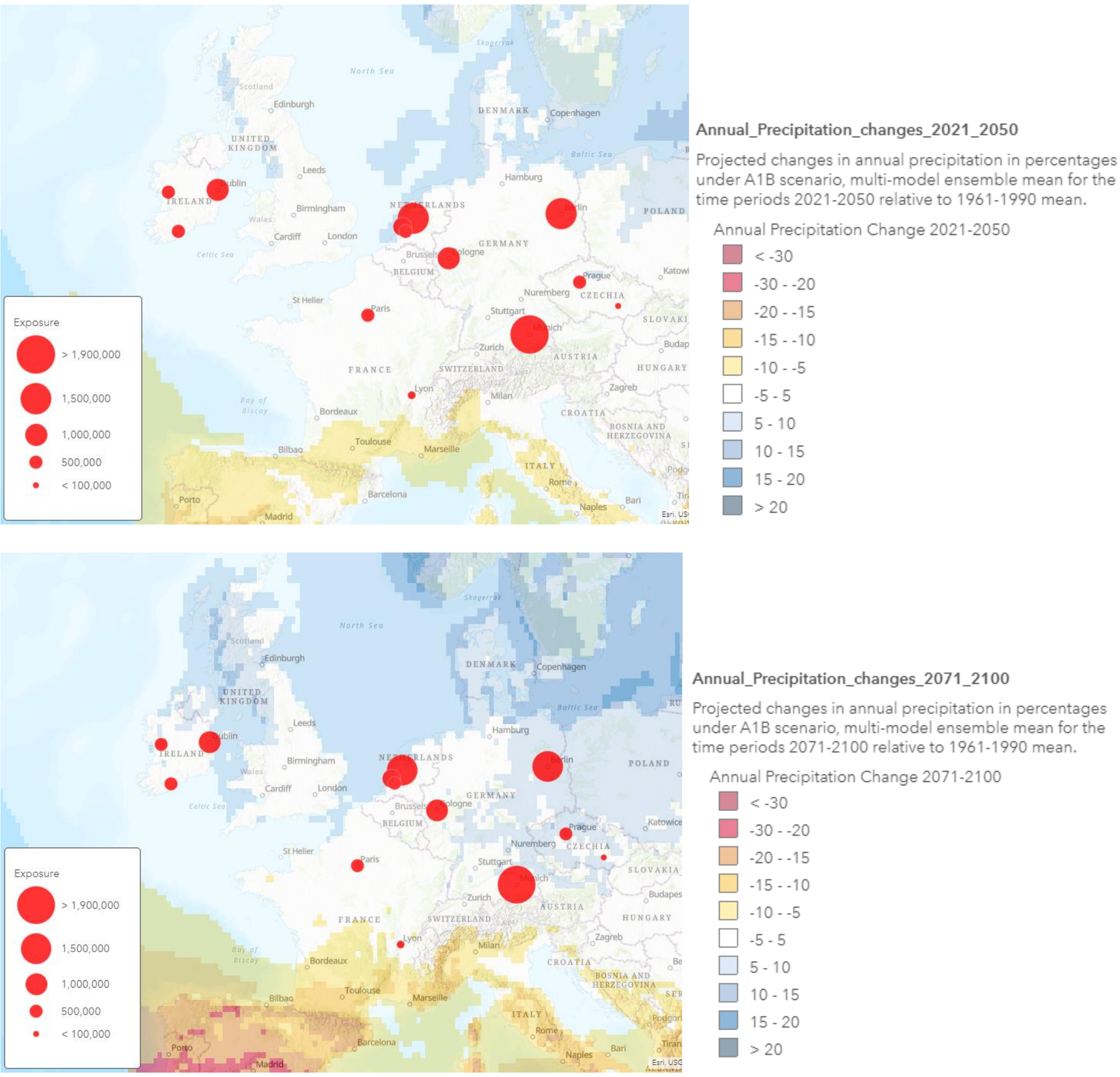


Figure 32: Projected changes in annual precipitation. Source: EEA[31].

[31] EEA - Services Monitoring (europa.eu)

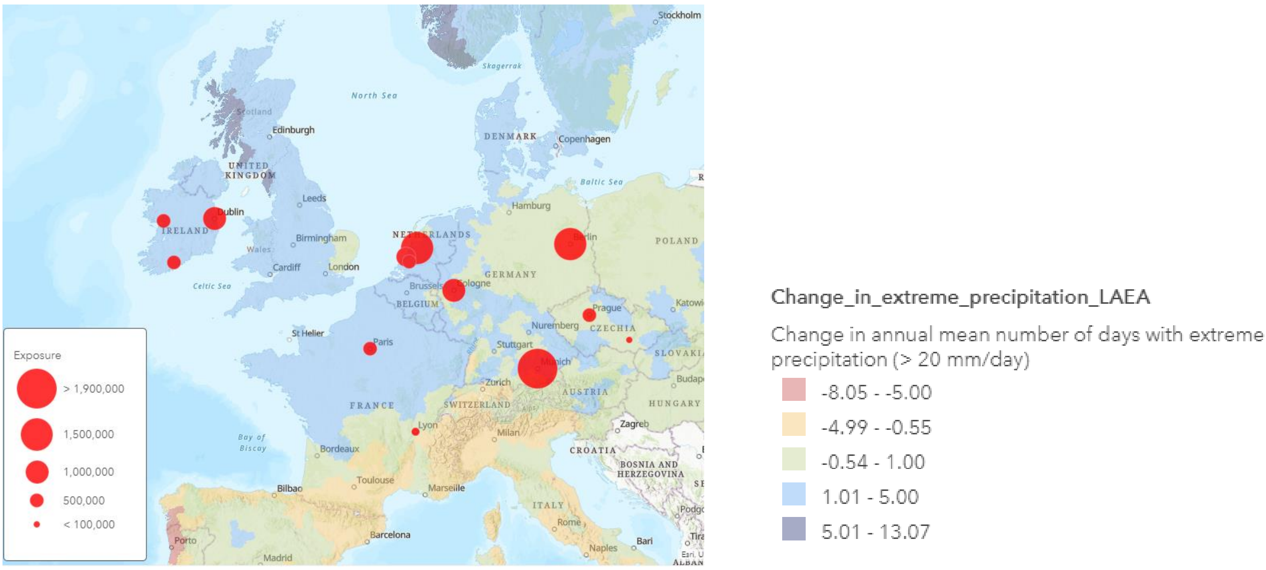


Figure 33: Projected changes in extreme precipitation. Source: EEA.

Pluvial floods and flash floods, which are triggered by intense local precipitation events, are likely to become more frequent throughout Europe.

(iii) Assessing relevance to the business

To assess the materiality, climate change and of course the size of the exposed value are taken into consideration. Most of the values are expected to be impacted by floods. The Table below shows an example of the analysis for coastal floods.

Country/Peril	Time horizon (term)	Max. exposed value (in million)	Climate change impact and probability on the exposure	Material for the dummy company?
Germany/coastal flood	Short	0.6	low/low	No, properties are not located along the coast
	Medium	0.6*	low/low	No, properties are not located along the coast

	Long	0.6*	low/low	No, properties are not located along the coast
Netherlands/ coastal flood	Short	0.4	medium/low	No, properties are exposed to climate change but size of exposure is overall low.
	Medium	0.4*	medium/medium	No, properties are exposed to climate change but size of exposure is overall low.
	Long	0.4*	medium/high	No, properties are exposed to climate change but size of exposure is overall low.
Ireland/ coastal flood	Short	0.3	low/low	No, locations are along the coast but size of exposure is small.
	Medium	0.3*	low/low	No, locations are along the coast but size of exposure is small.
	Long	0.3*	medium/low	No, locations are along the coast but size of exposure is small.
France/ coastal flood	Short	0.1	low/low	No, properties are not located along the coast
	Medium	0.1*	low/low	No, properties are not located along the coast

	Long	0.1*	low/low	No, properties are not located along the coast

Table 15: Analysis for coastal floods.

*The company could scale the exposure if it knew how the exposure would change in the coming years.

Finally, using the previous analysis the summarizing Table 16 has been created. Indeed, considering the size of the exposed value and the localization of the properties as well as how these properties could be impacted by climate change, the dummy non-life company doesn't expect the physical risk to be material for the non-life dummy-portfolio for a short/medium and even long time horizon.

The indication that there is an accumulation of risk for the properties located along the coast in the Netherlands could indicate to the dummy non-life company that they might want to invest in other properties.

Climate change risk		Time horizon (term)	Asset
Physical risk	Acute	Short	NM
		Medium	NM
		Long	NM
	Chronic	Short	NM
		Medium	NM
		Long	NM

Table 16: Summary of the materiality assessment for the physical risk and property investments.

For the dummy life company

(i) <u>Defining the business context</u>

The dummy life company holds in the portfolio 6.2 million Euro of property which relate to an office building used by the employees. It is assumed to be registered as the headquarter of the company and it is in the city center of a European capital. The property is insured against natural events.

(iii) <u>Assessing relevance to the business</u>

Using similar analyses as done for the non-life portfolio, the dummy life company decides not to consider this exposure as material in light of size and the location of the assets.

Climate change risk		Time horizon (term)	Asset
Physical risk	Acute	Short	NM
		Medium	NM
		Long	NM
	Chronic	Short	NM
		Medium	NM
		Long	NM

Table 17: Summary of the materiality assessment physical risk and property investments.

QUALITATIVE ANALYSIS FOR THE LIABILITY SIDE

The qualitative analysis will provide a first insight into the materiality assessment. After the qualitative analysis, extended analysis will also be performed on specific part of the liability side.

Using the dummy non-life company

(i) Defining the business context

The dummy non-life company operates mainly in Northern and Western Europe. Most of the insurance products offered are in Germany, the Netherlands, France and the UK. In each of the four countries the dummy company has a brand new local office. Insurance products offered to the remaining countries are done from these countries.

The underwriting portfolio of the dummy company is mainly comprised of (a) fire and other damage to property, (b) motor and (c) general liability. The dummy non-life company is highly exposed to natural catastrophes. Flood and windstorms are considered to be the most significant natural catastrophes. At the same time, the company is also interested to expand its property insurance coverage for natural catastrophes and is therefore interested to better understand for which type of coverages this would make sense also in the context of climate change.

(ii) Researching impacts of climate change on the business

Liability transition risk

The dummy non-life company underwrites to carbon-intensive sectors and is therefore exposed to events arising from or related to the energy transition. This risk can occur e.g. due to market sentiment changes, governmental policy measures or technological developments, that could accelerate the transition to a lower-carbon economy and harm the dummy non-life company's current underwritings, such as those from the motor insurance. The dummy company will suffer business contingency change losses. In the medium to long term the dummy company aims to reduce its exposure to carbon-intensive products and underwrite more electric cars insurance. Especially in the long-term the dummy company wants to avoid legal battles with investors or activist groups over its climate strategy and underwritings of general liability. Here the transition risk can materialize in terms of underwriting risk.

Liability physical risk

The underwriting portfolio of the dummy non-life company is mainly comprised of (a) fire and other damage to property, (b) motor and (c) general Liability. The dummy company is of the opinion that flood and windstorms are the highest risk to the underwriting portfolio as they can affect damage to property. The dummy company will incur losses when natural catastrophes happen, as the claims for damages will increase and the dummy company might not have sufficient capital to absorb these losses. This can impact the capital requirement needed for natural catastrophes for example as well as the technical provision. Considering that the dummy non-life company has an interest to expand its property portfolio, a quantitative analysis will be performed below.

(iii) Assessing relevance to the business

In the third step the undertaking is assessing the materiality of each risk on the liability side of the balance sheet.

From the physical perspective the dummy company is of the opinion that acute risk are more likely to materialize in the short, medium and long term on the liability side mainly for its fire and other damage to property portfolio.

From the transition risk perspective the dummy company expects that general liability insurance will be potentially impacted by litigation risks in the long term. Further the dummy company feels that if its current operations remain status quo it might face legal charges from investors and activist groups. Such actions will also affect its reputation.

Climate change risk		Time horizon (term)	Liability
Physical risk	Acute	Short	M (mainly fire and other damage to property)
		Medium	M (mainly fire and other damage to property)
		Long	M (mainly fire and other damage to property)
	Chronic	Short	NM
		Medium	NM

		Long	NM
Transition risk	Policy	Short	NM
		Medium	NM
		Long	NM
	Legal	Short	NM
		Medium	NM
		Long	M (mainly for GL insurance)
	Technology	Short	NM
		Medium	NM
		Long	NM
	Reputational	Short	NM
		Medium	M
		Long	M
	Market sentiment	Short	NM
		Medium	NM
		Long	NM

Table 18: Summary of materiality assessment.

*Note: *M stands for material, **NM stands for non-material.*

Using the dummy life company

(i) <u>Defining the business context</u>

Climate change will have a significant effect on society in the decades ahead but only a fraction of its deaths will be directly attributed to it. Besides natural disasters which will cause an increase of mortality in the affected areas, other examples of negative consequences in the long run might be:

- Increase in certain diseases, particularly if associated to the ageing of the population;
- Drought, heatwaves and resulting famine. This could also cause conflicts food-driven and heavy migrations;
- Worsening of air pollution

These effects are expected to significantly differ worldwide, with Asia and Africa being the continents where the impact is expected to be higher.

(ii) <u>Researching impacts of climate change on the business</u>

Due to this uncertainty over the future mortality trends and on the timing for it to crystalise, life companies will need to assess the presence of physical risk on the liabilities by assessing the appropriateness of the morbidity / mortality rates when the increase of them represents a risk for the company in the long run. The mortality / morbidity / hospitalization rates might be corrected by an adjustment which takes into account the nature of the portfolio and the expected impact of physical risk on the liabilities cash flows, by taking into account potential compensation effects (as an example, pension products which benefit from an increase of mortality might compensate the negative impact on traditional "term life insurance products") and potential mitigation techniques used (for example reinsurance or positions on longevity bonds or other alternative risk transfer products).

(iii) Assessing relevance to the business

The dummy life company expects physical risk to have an impact on the liabilities side only in the long run. However, this is expected not to have a concerning impact on the best estimate liabilities as the impact is expected to be only in the long term, when the liabilities cashflows of the solvency computation will be less significant.

Climate change risk		Time horizon (term)	Liability
Physical risk	Acute	Short	NM
		Medium	NM
		Long	M
	Chronic	Short	NM
		Medium	NM
		Long	NM

QUANTITATIVE ANALYSIS FOR THE LIABILITY SIDE

Liability and physical risks: TP

The below analysis shows examples on how to conduct a materiality assessment for physical risks on TP.

	Input data	Tool/Method
For non-life	Gross Technical Provisions per LoBs	EEA climate data
For life	Gross Technical Provisions per LoBs	Mortality under climate change

For the dummy non-life company

The below provides an example of how the impact of physical risks on the technical provisions can be assessed by LoB as well as taking into account the time horizon (short, medium, long). Please note that not all LoBs that the dummy non-life company writes are presented in the table below.

(i) Defining the business context

The LoBs which the dummy company writes and are expected to be impacted by physical risks are Fire and other damage to property insurance, Other Motor liability insurance and Marine, aviation and transport insurance. As indicated before, the dummy company covers Windstorm and Flood in policies written.

The Gross Technical provisions for these LoBs split into the Claim provisions and Premium provisions (Best estimate) and Risk Margin are the following:

LoB	Gross Technical Provisions	Gross Claims Provisions	Gross Premium Provisions	Risk margin
Fire and other damage to property insurance	9.5	8.7	-0.2	1
Other motor insurance	0.32	0.1	0.2	0.02
Marine, aviation and transport insurance	1.3	0.9	0.3	0.1

Table 19: Gross Technical Provisions for LoBs impacted by physical risk (in million EUR).

The claims provision is the discounted best estimate of all future cash flows (claim payments, expenses and future premiums) relating to claim events before the valuation date.

The premium provision is the discounted best estimate of all future cash flows (claim payments, expenses and future premiums due) relating to future exposure arising from policies that the (re) insurer is obligated to at the valuation date.

Note that in this case the Gross Premium Provision for Fire and other damage to property insurance is negative as the expected present value of cash inflows exceeds that of cash outflows.

Physical risk is expected to impact these LoBs through higher frequency and higher severity weather related events. The change in the frequency and severity will depend on the geographical location of the insured properties. If the exposure is high in particular locations, this could result in accumulations of risk.

(ii) Researching impacts of climate change on the business

The dummy company writes business in various parts in Europe and the UK but has a large exposure to Germany, France, Netherlands and UK.

For the above regions, it is expected that there will be an increase in frequency and severity of claims. For a more accurate analysis, the exact geographical location of the insured properties should be analyzed. Additionally, it should be assessed if there is a concentration of properties in specific locations as this could result in accumulations of risk.

Taking into account the impact of climate change in the table below, it is likely that properties insured in Germany will suffer in the short term from higher frequencies of wildfire and flood. Properties insured in Netherlands will experience higher frequencies of wildfire, and flood, whereas properties in France and UK could also be affected by flood.

The heavy rainfall and flooding will affect mainly the Fire and other damage to Property insurance LoB where these perils are covered in the policies. The Other Motor LoB will not be greatly affected since the dummy company has only a small proportion of comprehensive insurance covers which also cover flood. Additionally, increased hailstorm events could impact the Marine Hull insurance policies in the medium and long term, however the dummy company is planning to slowly decrease the amount of business written in this LoB.

The dummy company is currently using deterministic actuarial techniques to assess the earned claims reserves with the present value of cash flows calculated by applying a payment pattern to the reserves to generate future cash flows. Additionally, the company projects the future cost for natural catastrophes separately from attritional and large losses.

The historical development pattern for weather related claims may no longer be appropriate due to the climate change trends as well changes in seasonality so this will be revised.

For the premium provision, a loss ratio is applied to the unearned premium to estimate the total claims and then a payment pattern is applied to generate future cash flows.

The loss ratio to use for each LoB should be adjusted to reflect the future exposure taking into account the changes expected from physical risks.

Considering that the flood risk in Germany, France and the UK will be material for the dummy company in the short, medium and long term, the loss ratios used in the premium provision calculation per LoB are expected to increase. The proportion by which the loss ratio would increase corresponds to the exposure to flood in the policies written for each of the LoBs.

(iii) Assessing relevance to the business

To assess the materiality, the size of the technical provisions are taken into consideration as well as the dummy company's exposure over the different time horizons:

Since the dummy company's business is mainly in property, the impact of physical risk on this LoB is expected to be material, whereas for other motor insurance and marine, aviation insurance is not expected to be material.

LoB	Time horizon	Materiality assessment for the dummy non-life company
Fire and other damage to property insurance	Short	M
	Medium	M
	Long	M
Other motor insurance	Short	NM
	Medium	NM
	Long	NM
Marine, aviation and transport insurance	Short	NM
	Medium	NM
	Long	NM

Table 20: Materiality assessment for LoBs impacted by physical risk *NM non-material/M material.

For the dummy life company

In the previous sections it was shown how climate change might cause changes in the (long-term) trend underlying the evolution of future mortality rates. This risk is relevant for insurance products which pay out contingent on survival (e.g., "annuities") or death (e.g., "term life insurance products") of the insured person.

Input data	Tool/Method
Amount, average age and location of TP by LoB	Mapping Life TPs to physical risk drivers

(i) Defining the business context

The underwriting portfolio of the dummy life company is comprised of "with profit participation products" (93%) with a minority of other life products (5.8%) which include "term life insurance products". The company has recently included unit / linked products to their offer. The company would like to understand how, and if, its life liabilities portfolio is exposed to physical risk.

The company considers negligible the impact of physical risk on underwriting for the unit linked business but is willing to understand the risk included in the TP for "with profit participation products" and in "other liabilities".

Technical Provision	Amount
Technical provisions – With profit participation	88.0
Technical provisions – Other liabilities	5.5
Technical provisions – Unit / Index linked	1.2

Table 21: Technical provisions by LoB in million EUR.

(ii) Researching impacts of climate change on the business

There has been progress in the literature in assessing the impact that an increase in the temperature would have on the mortality by using specific environmental scenarios which might help in the calibration of the expected difference in mortality, topic still subject to a very high degree of uncertainty. An example of these approaches is provided by Carleton et al. (2021) who provides an empirically-derived estimates of climate change's impacts on global mortality risk.

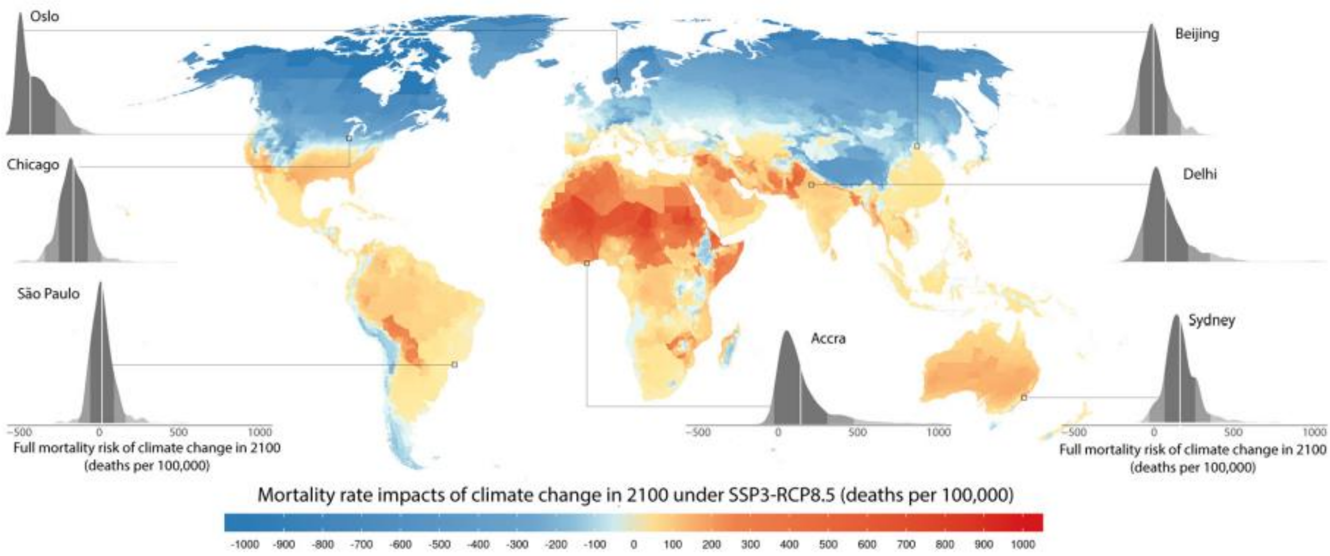


Figure 34: The mortality impact of climate change (Carleton, 2021).

(iii) Assessing relevance to the business

Despite being small, the dummy life company is active on the cross border business and its liabilities, below, are geographically diversified even if they tend to stay within the Mediterranean region.

The "with profit participation products" of the dummy life company are mainly affected by lapse risk, which is the main Life underwriting risk in the Risk profile. However, some products include the payment of a contingency in case of death.

With profit participation products _ TP	Amount	Weight
Italy	15.0	17%
Spain	40.0	45%
Portugal	28.0	32%
France	5.0	6%
	88.0	

Table 22: With profit participation TP – Breakdown by country in million EUR.

The other life products portfolio comprises only "term life insurance products", where mortality is the main underlying risk. An increase of the mortality rates would lead to an increase of the outflows due to the occurrence of the insured event. On the other hand, due to the specific features of the portfolio, lapse and expense risk are considered not materially affected by physical risk.

Other Life Products_TP	Amount	Weight
Spain	4.6	84%
Portugal	0.9	16%
	5.5	

After the analysis of the geographical component the company decides to further break down the portfolio by average age of the policyholders because the demographic component is considered another important parameter to take into account. Although probably the demographical parameter will not affect the increase of deaths due to natural events, it might do so when assessing the increase in the circulation of diseases that an increase in the temperature would have.

The dummy life company for the "with profit participation" portfolio, the following breakdown shows how the average age varies within the four countries in which the dummy company operates, with the peak being Portugal.

With profit participation products	Average age
Italy	36
Spain	44
Portugal	63
France	51

The "term life insurance products" present a less international background and a similar overall average age. However, the "term life insurance products" portfolio is considered to be particularly exposed to mortality due to the intrinsic nature of the business, so that changes in mortality would potentially harm the financial structure of the undertaking.

Other Life Products	Average age
Spain	46
Portugal	62

Table 23: Other Life TP – Breakdown by country and average age.

The analysis above could be performed on a more granular level (until product level). It would allow the company to better identify where the risk might exist and prepare more tailored mitigation actions.

The reclassification of the portfolio by geography and demography helped to draw some conclusions over the potential presence of physical risk in the liabilities profile.

The "with profit participation" portfolio is not particularly affected by an increase of the mortality rates, therefore the company considers the impact of physical risk on these LoB not material.

However, the company acknowledges that there might be some risk within the "term life insurance products", where an increase of the mortality rates is expected to have an impact in the long run.

Climate change risk	LoB	Time horizon (term)	Liability (M/NM*)
Physical Risk	With profit participation	Short	NM
		Medium	NM
		Long	NM
	Other Life insurance	Short	NM
		Medium	NM
		Long	M

Table 24: Materiality assessment for LoBs impacted by physical risk *NM non-material/M material.

Liability and transition risks: TP

The below analysis shows examples on how to conduct a materiality assessment for transition risks on TP.

	Input data	Tool/Method
For non-life	Gross Technical Provisions per LoBs	Litigation information
For life	Gross Technical Provisions per LoBs	Mortality under climate change

For the dummy non-life company

The below provides an example of how the impact of transition risks on the technical provisions can be assessed by LoB as well as taking into account the time horizon (short, medium, long). Please note that not all LoBs that the dummy non-life company writes are presented in the table below.

(i) Defining the business context

The LoB expected to be impacted by transition risk (category litigation risks) for the dummy company is general liability.

The dummy company writes mainly Directors and Officers (D&O) (60%) and Professional Indemnity (40%) under general liability in Germany and the Netherlands.

The Gross technical provisions for general liability split into the claim provisions, premium provisions and risk margin are shown below in EUR and in 000s:

LoB	Gross Technical Provisions	Gross Claims Provisions	Gross Premium Provisions	Risk margin
General liability insurance	5	4	0.2	0.8

Table 25: Gross technical provisions for LoBs impacted by transition risk in million EUR.

It can be observed that while the dummy non-life company has a relatively small proportion of written premium in general liability (6%), the technical provisions amount for this LoB in relation to the total amount is a lot larger (25%). This is due to the nature of the liability LoB being long-tailed with claims developing slower than property. Additionally, the liability could be unlimited and hence it could result in very large claims where court inflation could also exacerbate the size of the claims.

Transition risk and more specifically litigation risk is expected to impact the LoBs written under general liability through lawsuits initiated by third parties against the insured person due to their potential contribution to the negative impact of carbon emissions.

Litigation risk can have an impact on the D&O LoB through higher severity claims and expenses since there will be firstly high defense costs arising out of possible criminal and regulatory investigations. The directors might be sued for various reasons including failure to mitigate greenhouse gas emissions, failure to change their investment strategies and failure to comply with environmental regulations.

However, certain D&O policies might not cover certain types of claims and costs and thereby climate related litigation claims might fall upon the director or officer. Additionally, there could be some exclusions in the policy such as pollution exclusions and as a result the insurer might not be liable to pay the claim.

(ii) Researching impacts of climate change on the business

Currently, the dummy company has not included energy companies in its D&O portfolio, however directors and officers of other private companies could be sued over failure to disclose climate change risks or adapt their business practices in line with the changing climate environment.

The number of cases filed and the number of countries within which they have been brought have increased rapidly in recent years[32] i.e., in 2017 there were 884 cases in 24 countries compared to 1 July 2020 where the cases nearly doubled with 1550 climate cases in 38 countries.

Furthermore, security class actions are rising globally as legal environments evolve and claim propensity increases. While this is most prevalent in the US, Canada and Australia, Netherlands and Germany are showing remarkable development and increased activity in recent years. Given this development, it is expected that litigation actions will increase in the future and so companies will run a greater risk of having a lawsuit brought against them in these jurisdictions.

The map below[33] indicates the risk of a company having a securities group action filed against it in various jurisdictions around the globe. It can be seen that for Germany there is a developed litigation funding market with activity being on the increase and new mechanisms recently introduced which could see further claims. Similarly, Netherlands has also a developed litigation fund market with effective mechanisms in place and further legislative reforms are in the plan to develop the class action landscape.

[32] UN Environment Programme, Global Climate Litigation Report 2020

[33] Allianz Global Corporate & Specialty SE, Collective Actions and Litigation Funding and the Impact on Securities Claims: A global snapshot

Figure 35: Collective actions and litigation funding: A global snapshot (Clyde& Co, AGCS).

The dummy company provides Professional indemnity insurance mainly to Architects and Engineer professionals.

Engineers and construction companies could face lawsuits where the construction of commercial or domestic buildings do not meet the energy efficiency requirements as indicated in the initial contracts and thereby not contributing to reducing the greenhouse gas emissions and subsequently the transition to low carbon economy.

Regarding these lines of business there is relatively little history of climate related litigation and as a result the data used by the dummy company needs to be adjusted to allow for the possibility of these claims.

In order to run an analysis on the litigation risk, undertakings could also consider to use a similar method as presented in the above section for the asset side which looks at the investment portfolio alignment to specific climate scenarios and can then detect the probability that the firms the insurer is investing in would have to a litigation risk (i.e. the less aligned the companies are to a 1.5°C scenario the higher the probability to have litigation risks). The same could be done by analyzing the companies insured under Directors and Officers or Professional Indemnity for example.

(ii) <u>Assessing relevance to the business</u>

To assess the materiality, the size of the technical provisions are taken into consideration as well as the dummy company's exposure over the different time horizons:

LoB	Time horizon	Materiality assessment for the dummy non-life company
General liability insurance	Short	NM
	Medium	NM
	Long	M

Table 26: Materiality assessment for LoBs impacted by transition risk *NM non-material/M material.

For the dummy life company

Transition risk might have its direct impact also on the liabilities side and not only via the change in values in the assets it would lead to. During the transition phase, pollution will benefit from a reduction in the level of vehicles with internal combustion engine which, together with new emerging policies / technologies would lead to a reduction in carbon emissions. This would be expected to lead to a decrease in mortality rates.

(i) Defining the business context

In the previous section an analysis of the TP by LoB has been performed. See here the breakdown by LoB:

Technical Provision	Amount
Technical provisions – With profit participation	88.0
Technical provisions – Other liabilities	5.5
Technical provisions – Unit / Index linked	1.2

Table 27: TP breakdown by LoB in million EUR.

Where the with-profit participation products and the “term life insurance products” included in the LoB “Other Liabilities” triggers a payment in case of death. The dummy life company does not hold pension products in the portfolio.

(ii) Researching impacts of climate change on the business

It is widely accepted that long-term exposure to air pollution contributes to risk of mortality—especially due to e.g. cardiopulmonary and lungs diseases among others. According to WHO, air pollution is responsible for around 7 million yearly deaths in the world, with more than 90% of the population being exposed to air which exceeds the limits set by the WHO.

However, the transition phase requires a rapid reduction in fossil-fuel power plants and a higher use of renewable energies, which is expected to have a positive long term impact on the mortality rates due to the reduction of pollution-related diseases.

(iii) Assessing relevance to the business

The risk profile of the company highlights how longevity would have a positive impact on the undertaking in terms of reduction of the outflows. If transition risk will lead to a decrease of the mortality rates the company would expect this to be beneficial for its solvency.

Climate change risk	LoB	Time horizon (term)	Liability (M/NM*)
Transition Risk	With profit participation	Short	NM
		Medium	NM
		Long	NM
	Other Life insurance	Short	NM
		Medium	NM
		Long	NM

Table 28: Summary of the materiality assessment. *NM non-material/M material.

Liability and physical risks: Nat Cat UW risk

The below analysis shows examples on how to conduct a materiality assessment for transition risks on TP.

	Input data	Tool/Method
For non-life	Localization of sum insured, nat cat SCR	EEA climate data

For the dummy non-life company

The below provides an example analyses the nat cat UW portfolio. The following analysis is made at country level but a more detailed analysis at regional level could also be performed and would allow for more accurate results.

(i) Defining the business context

The graph below shows exposure from the "dummy" non-life company expressed as sum insured for two nat cat perils (Flood and Windstorms), which are potentially impacted by climate change. Earthquake exposure has not been considered as the impact of climate change is expected to be minimal. The main nat cat exposure can be seen for Germany, Netherlands, UK and France. The highest exposure is seen for windstorms.

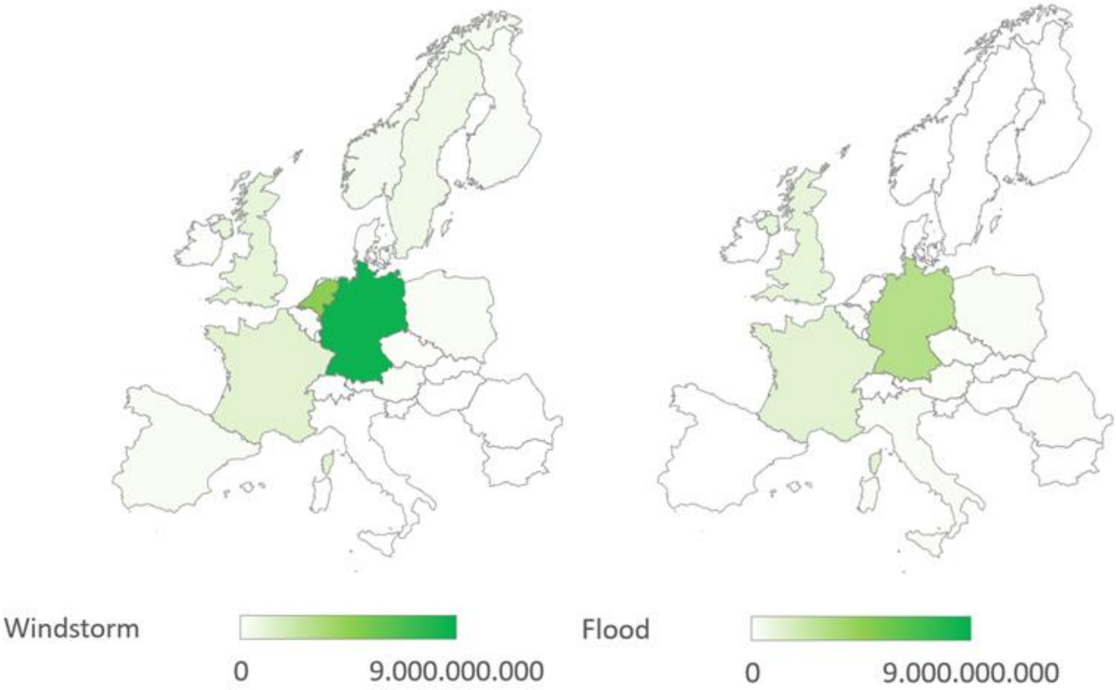


Figure 36: Exposure of the dummy non-life company to for flood and windstorm in EUR.

Understand how the risk relates to the exposure:

The SCR values allows to see where the risk is the highest. Indeed, depending on the type of peril, even if the exposure is high the resulting risk can still be low. Main nat cat risk can be seen for Germany, the Netherlands, UK and France. Windstorm risks are the highest but flood risks also show to be important for the portfolio.

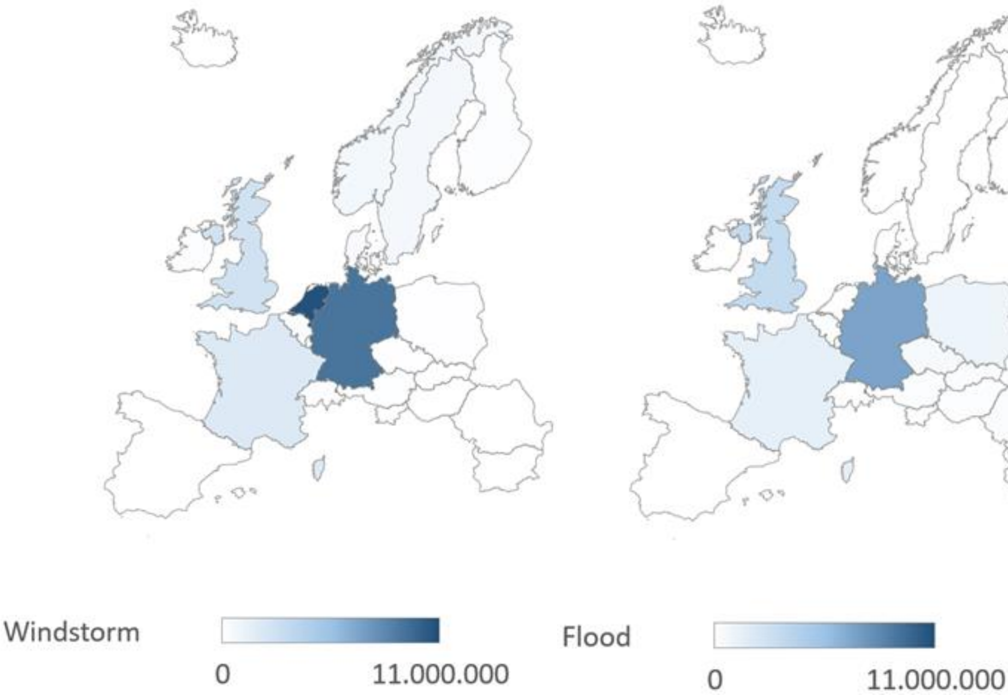


Figure 37: SCR values for flood and windstorm before mitigation in EUR.

Reinsurance plays an extremely important part to reduce the nat cat risks for the dummy company. This is particularly important for Germany windstorms and floods and Netherlands windstorms.

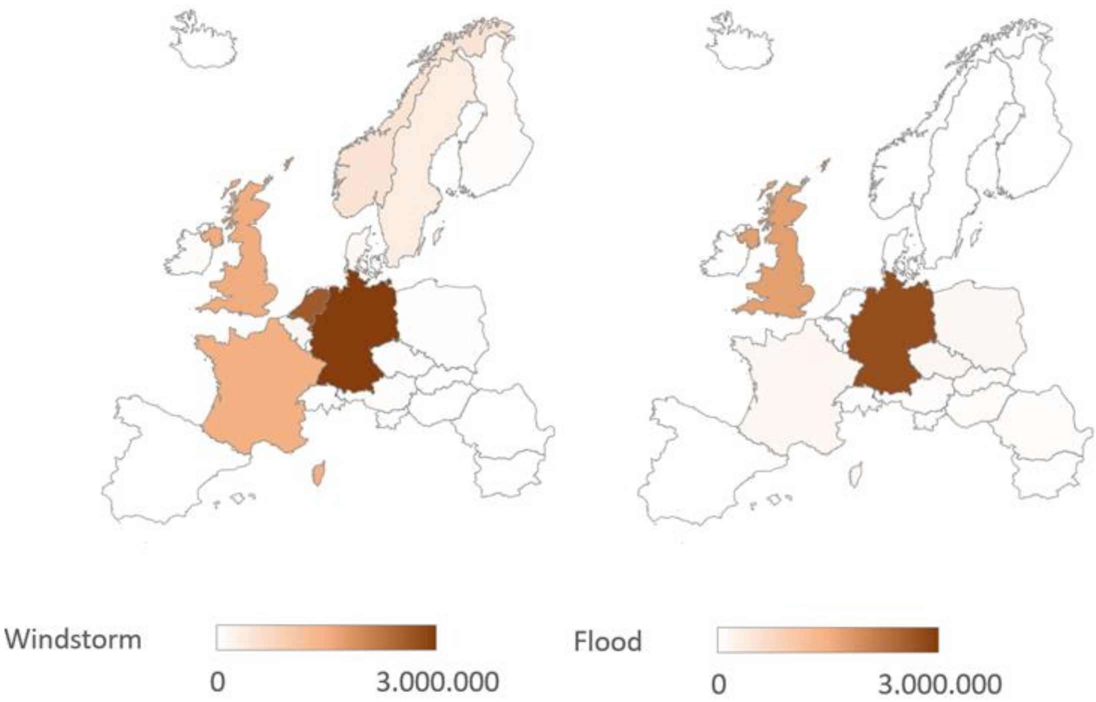


Figure 38: SCR values for flood and windstorm after mitigation in EUR.

The nat cat insurance contracts are renewed on a short time horizon however, the dummy non-life company would also be interested in expanding their property insurance portfolio. It is therefore key to understand where climate change has/will have an impact for the next 10 to 30 years.

(ii) <u>Researching impacts of climate change on the business</u>

Now that the exposure's location is known as well as which perils are covered, the specific exposure/risk is impacted by climate change can be analysed. Climate change impacts will vary significantly between different types of perils as for different geographical locations.

The map from the EEA (see Figure 41 below) shows for example that in the Mediterranean region, less river floods are expected. On the other hand, higher river floods are expected in the Atlantic and Continental regions.

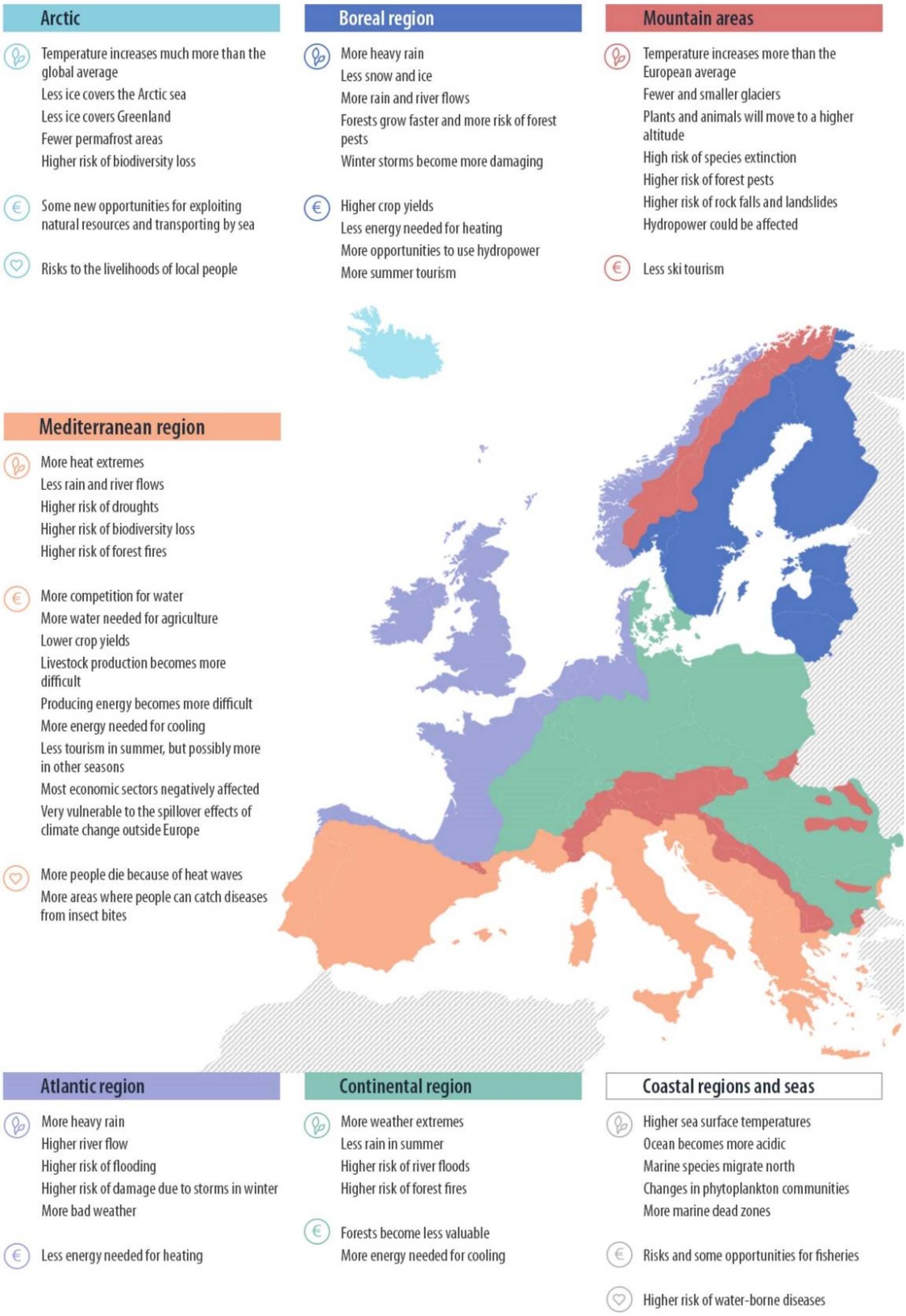


Figure 39: The impact of Climate change in Europe (EEA, 2017).

In addition, depending on the type of peril there is more or less evidence about the impact of climate change. EIOPA's methodological paper on potential inclusion of climate change in the Nat Cat standard formula, for example concluded that currently not much evidence is seen on the impact of climate change on windstorms for example. The number of reported windstorms significantly increased over the last decades, yet there is no consensus about a climate-induced trend in windstorms over Europe. Climate models suggest that windstorms will not become more intense or happen more frequent with global warming over most of the European land. As a consequence, it is expected that risks from windstorms in the EU will not rise due to climate change (Spinoni et al., 2020).

Risk	**Current impact of climate change**		**Next 5-10 years projection[34]**	
	Evidence of impact	**Most affected regions in Europe**	**Projection of impact**	**Most affected regions in Europe**
Temperature-related				
Wildfire	Yes	Southern, western and central Europe	Yes	Southern, western and central Europe
Wind-related				
Windstorm	No		No	
Water-related				
Heavy precipitation	Yes	Northern and north-eastern Europe	Yes	Scandinavia and northern Europe in winter
River floods	Yes	North-western and parts of central Europe	Yes	Most of Europe except parts of northern Europe and southern Spain

[34] Impact of climate change under 1,5°C warming projection.

Hail	Plausible in some regions	Alpine countries including northern Italy and Balkan countries	Yes	Mediterranean, central and eastern Europe
Drought	Yes	Southern Europe	Yes	Most of Europe, especially southern Europe and except northern Europe
Solid mass-related				
Subsidence	Yes	Soils with substantial fraction of clay (e.g. France)	Yes	Soils with substantial fraction of clay (e.g. France)

Table 29: Summary of the analysis, highlighting the risks with broad evidence and high confidence of the impact of climate change and identified the most affected European regions.

(iii) <u>Assessing relevance to the business</u>

Considering the dummy non-life portfolio, it can therefore be assumed that the flood risk in Germany is expected to become higher due to climate change. Other countries are also relevant for the dummy portfolio such as UK, Poland and France for flood risks in the context of climate change.

To assess the materiality, the impact of climate change and the size of the impacted exposed value are taking into consideration.

Country	Peril	Max. exposed value (in million)	SCR (in million)	Climate change impact and probability on dummy exposure	Material for the dummy company?
Germany	Flood	3000	7	medium/medium	Yes
Germany	Windstorm	8,500	9	low/low	No
Netherlands	Windstorm	4,700	10	low/low	No

France	Flood	1,200	1.4	medium/medium	Yes
France	Windstorm	1,200	2	low/low	No
UK	Flood	0,950	3.3	medium/medium	Yes
UK	Windstorm	0,950	2.5	low/low	No
Poland	Flood	0,200	0.9	low/medium	Yes

Table 30: Combining the exposure and the impact of climate change for the short term horizon.

The portfolio does not have any exposure to chronic risks as these are not covered by the dummy non-life company.

Finally, using the previous analysis and considering the fact that very high exposures are impacted by climate change physical risks the below table has been created.

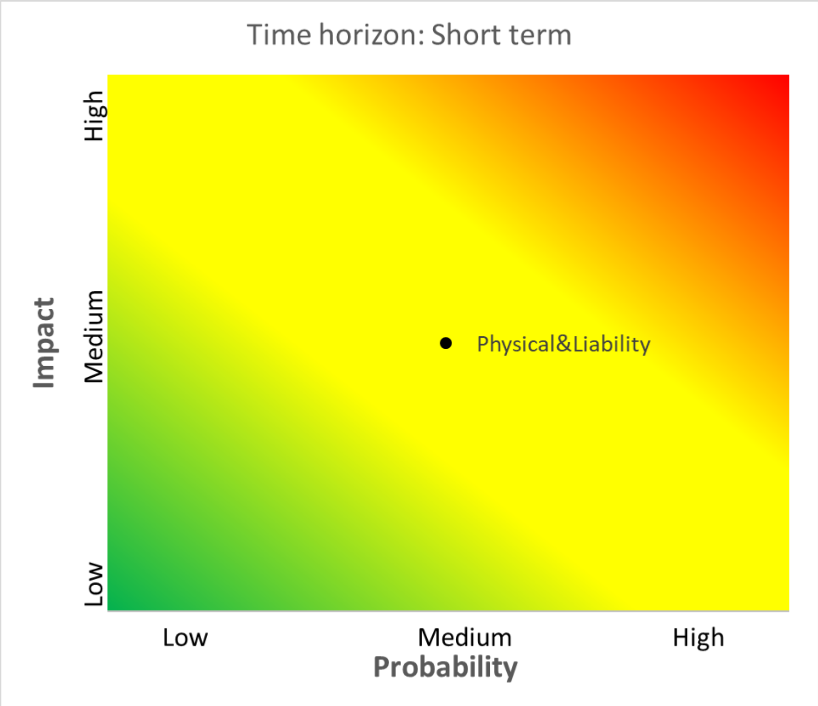
Climate change risk		Time horizon (term)	Liability (M/NM*)
Physical risk	Acute - Flood	Short	M
		Medium	M
		Long	M
	Chronic	Short	NM
		Medium	NM
		Long	NM

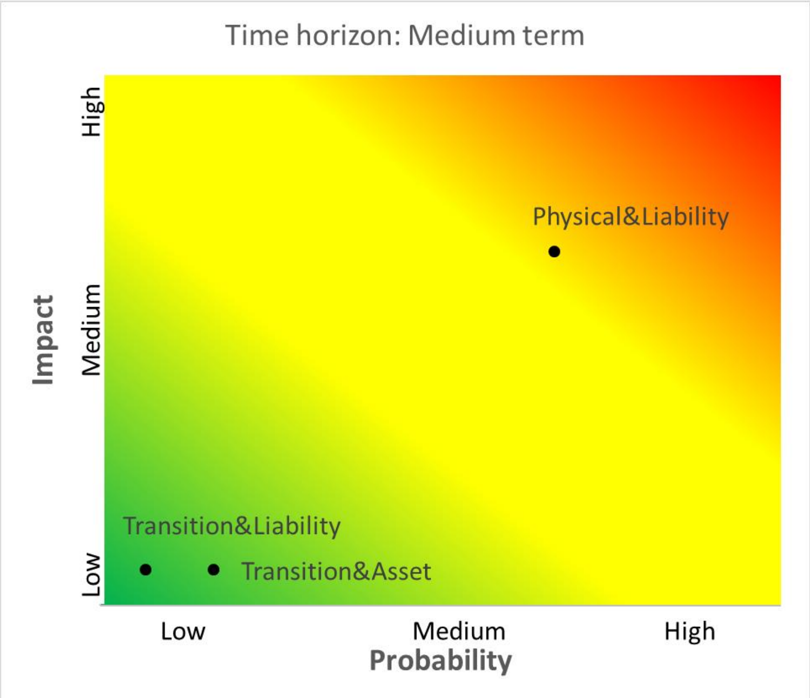
Table 31: Summary of the materiality assessment. *NM non-material/M material.

CONCLUSION FOR THE DUMMY NON-LIFE COMPANY

The below materiality matrices combines the findings from the above qualitative and quantitative analyses for the dummy non-life company. The qualitative analysis provided first insights which are then complemented by the quantitative analysis.

The analysis done above also allows to compare the relative importance of the different risks to each other. The assessment shows that the most prominent risk for the dummy non-life company is linked with physical risks on the liability side.


Time horizon: Short term
Impact
High
Medium
Low
Physical&Liability
Low
Medium
High
Probability


Time horizon: Medium term
Impact
High
Medium
Low
Physical&Liability
Transition&Liability
Transition&Asset
Low
Medium
High
Probability

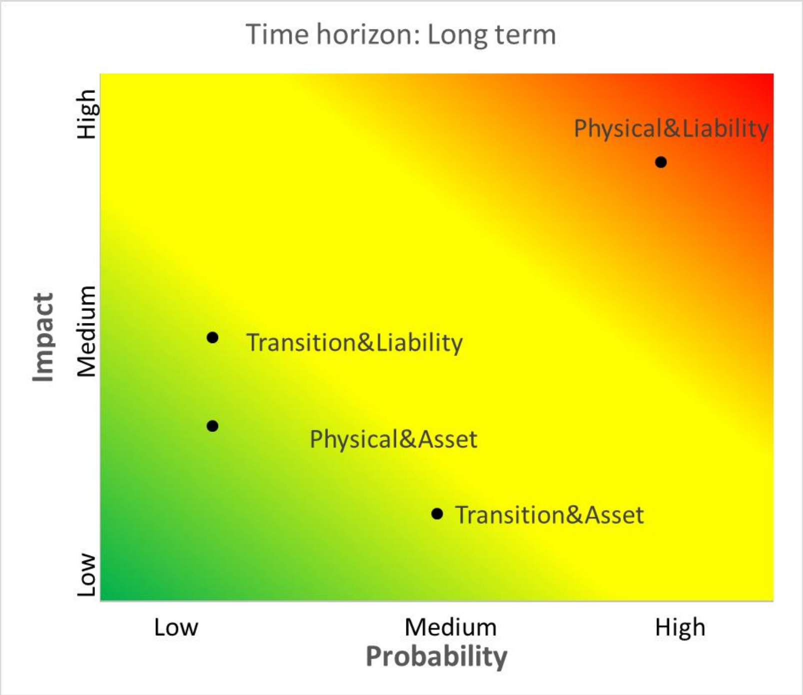
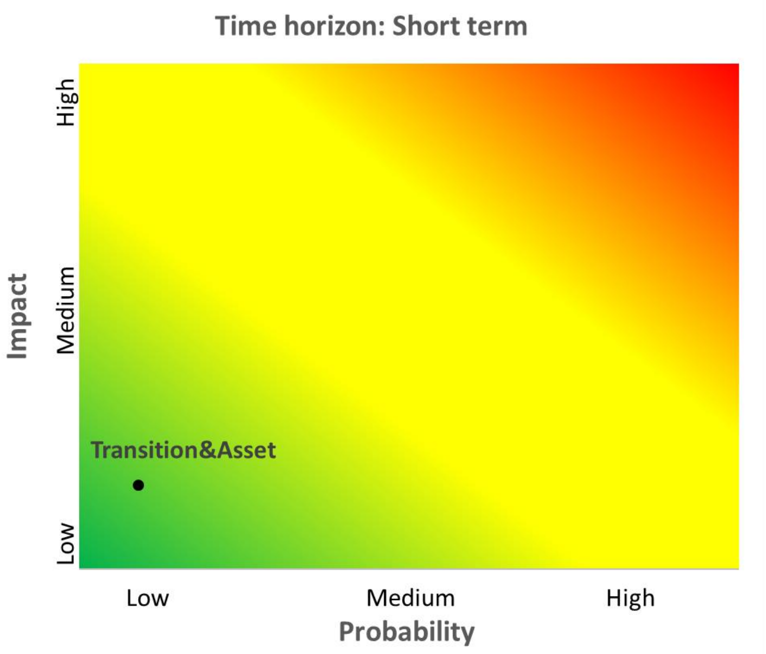


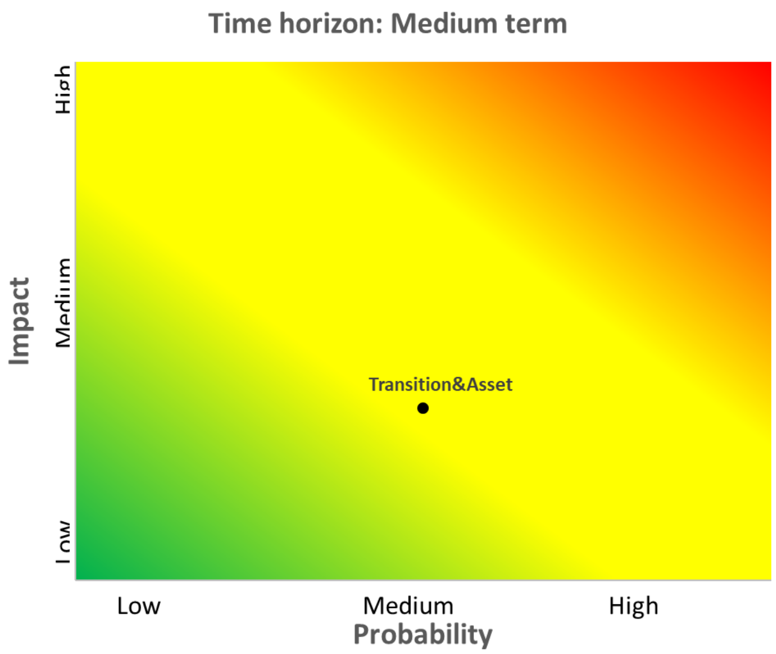
Figure 40: Materiality assessment for dummy non-life company.

CONCLUSION FOR THE DUMMY LIFE COMPANY

The below materiality matrices combines the findings from the above qualitative and quantitative analyses for the dummy life company. The qualitative analysis provided first insights which are then complemented by the quantitative analysis.

The analysis done above also allows to compare the relative importance of the different risks to each other. The assessment shows that the most prominent risk for the dummy life company is linked with transition risks on the asset side.


Time horizon: Short term
Impact
High
Medium
Low
Transition&Asset
Low
Medium
High
Probability


Time horizon: Medium term
Impact
Transition&Asset
Low
Medium
High
Probability

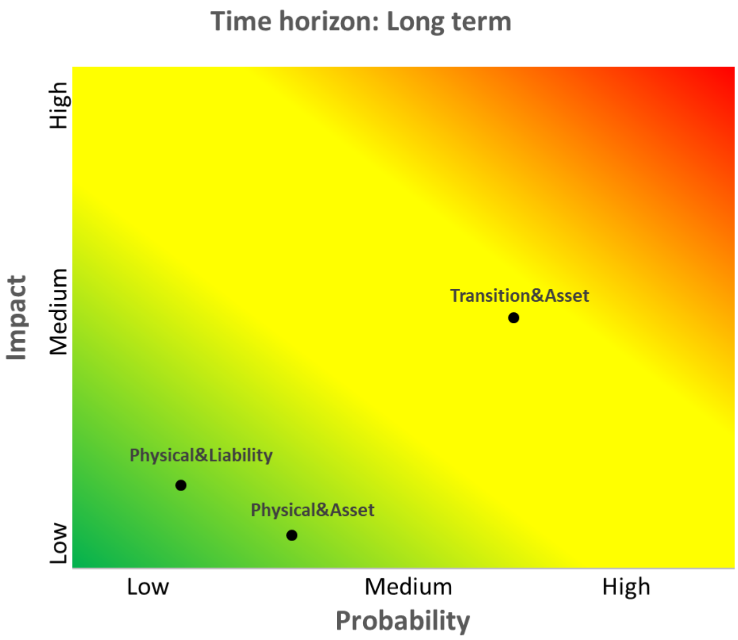


Figure 41: Materiality assessment for dummy life company.

CLIMATE CHANGE SCENARIOS

CLIMATE CHANGE SCENARIO ANALYSIS FOR THE DUMMY NON-LIFE COMPANY

The below analysis will focus at physical risk on the liability side as this was clearly identified as been a material risk for the dummy non-life company. In particular, the materiality assessment of the dummy non-life company has shown that flood risk could be important in the context of climate change for the dummy company. Four ways to perform scenario analysis on flood risks will be considered.

The four different ways to perform the scenario on flood risks have been chosen to show different sources of data to be used for such analysis but also the advantages/disadvantages associated with each of them.

As mentioned in the materiality assessment, the nat cat insurance contracts are renewed on a short time horizon however, the dummy non-life company would also be interested in expanding their property insurance portfolio. It is therefore key to understand where climate change has/will have an impact for the next 10 to 30 years.

In order to define the physical risk scenarios, two parameters are important to be defined:

- the time horizon at which the analysis should be conducted;
- the GHG emission pathway to be considered.

Depending on the type of climate change risk and insurance activities considered, the companies might consider different time horizons. For setting a proper analysis, it is important to clearly define the time horizon considered.

Using the NGFS Climate impact explorer

The climate impact explorer tool[35] shows how the severity of climate change impacts will increase over time in continents, countries and provinces at different levels of warming, starting with 1.5°C, the limit in the Paris Agreement. It also allows access to the underlying data.

Input needed for running the analysis using the NGFS climate impact explorer

Input data	Tool/Method
SCR by location per peril	NGFS Climate impact explorer

Scenario narrative

The following scenarios are considered:

- Scenario 1 - RCP 2.6 and a time horizon = 2030: consider a time horizon of 10 years and a warming scenario which is below the 1.5°C (at the end of the century);
- Scenario 2 - RCP 2.6 and time horizon = 2040: consider a time horizon of 20 years and a warming scenario which is below the 1.5°C (at the end of the century);
- Scenario 3 - RCP 8.5 and time horizon = 2030: consider a time horizon of 10 years and a warming scenario above 2°C (at the end of the century);
- Scenario 4 - RCP 8.5 and time horizon = 2040: consider a time horizon of 20 years and a warming scenario above 2°C (at the end of the century);

[35] Climate Analytics — Climate impact explorer

Physical risks

Using the NGFS Climate impact explorer, the changes in annual expected damage from river flood compared to year 2020 will differ significantly for the different scenarios described above.

The annual expected damage by river floods is given in 2005 US$, and is defined as the level of damage from such events that is expected to occur every year on average. Projections were calculated assuming that both the size and the repartition of GDP would stay constant as of 2005.[36][37]

[36] The exposure estimate for the damage calculation corresponds to the method previously applied in Sauer et al. (2021). Gridded Gross Domestic Product (GDP) data for the year 2005 from the ISIMIP project are used as a proxy for the distribution of assets. They have a spatial resolution of 5 arcmin and are reported in purchasing power parity (PPP) in 2005 USD. The data were obtained using a downscaling methodology in combination with spatially-explicit population distributions 10 from the History Database of the Global Environment (HYDEv3.2), and national GDP estimates. To provide a suitable asset indicator estimate gridded, the GDP data are translated into gridded capital stock, using annual national data on capital stock (in PPP 2005 USD) and GDP from the PennWorld Table (version 9.1, https://www.rug.nl/ggdc/productivity/pwt/). For each country the annual ratio of national GDP and capital stock was calculated and smoothed with a 10-year running mean to generate a conversion factor, which was then applied to translate exposed GDP into asset values for the year 2005. The final exposure dataset is the global distribution of capital stock on a 150 arcsec resolution (which equals a ~4.5km x ~4.5km at the equator) corresponding to the year 2005

[37] Projected changes in flood fraction and flood depth were obtained with established global hydrological models, which nevertheless depict a simplified, hence imperfect representation of the evolution of flooding under climate change. They were forced with a limited number of climate model simulations; therefore despite the efforts to account for this while pre-processing the data, short-term fluctuations can reflect the influence of natural climate variability rather than the response to anthropogenic climate change. Furthermore, a global time-independent damage function was applied to translate the changes in flood fraction and depth into damages, thus not accounting for country-specific vulnerabilities and their future changes. The confidence in the results decreases for high warming levels, which have been attained in a smaller number of the climate model simulations underlying these results, and especially as of 2.5-3°C of global warming.

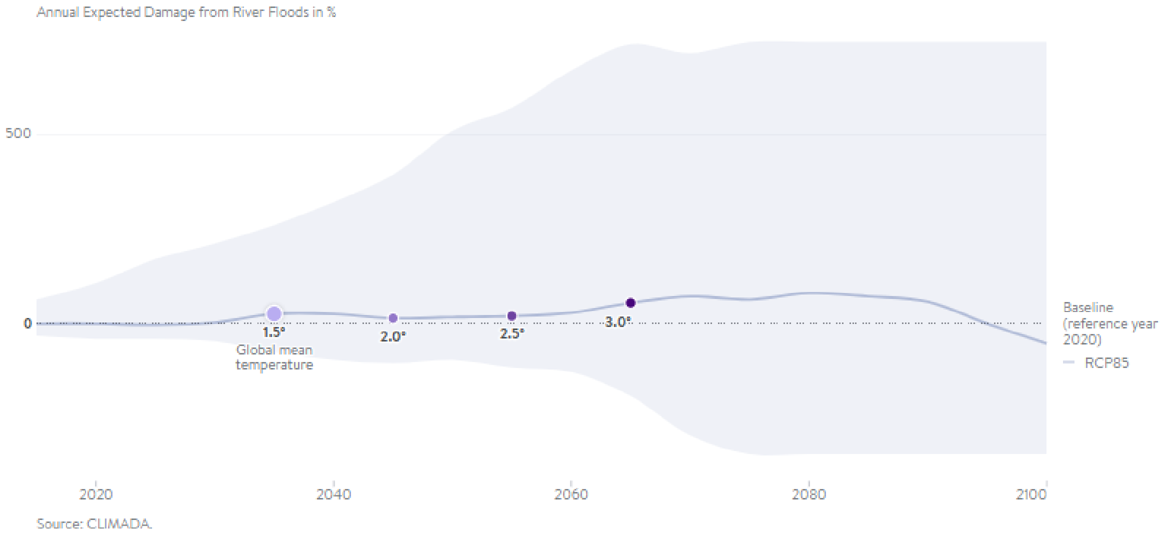


Figure 42: This graph shows how relative changes in Annual Expected Damage from River Floods (expressed in percent) will play out over time in France at different global warming levels compared to the reference year 2020, based on the RCP8.5 scenario[38].

[38] for the median, upper and lower bounds.

Country	Time horizon	RCP 2.6	RCP 8.5
France	2030	-7%	0.3%
France	2040	10.1%	23.6%
Germany	2030	21.7%	26.4%
Germany	2040	32%	78.4%
Poland	2030	25.4%	44.1%
Poland	2040	69.9%	270.9%
UK	2030	53.9%	94.2%
UK	2040	121.1%	132.4%
Czech Republic	2030	30.5%	42.1%
Czech Republic	2040	48%	48%

Table 32: Relative changes in Annual Expected Damage from River Floods (expressed in percent) will play out over time in different countries in Europe at different global warming levels compared to the reference year 2020 (median values).

Loss estimation

Using the relative changes in annual expected damage from river flood per country shown in Table 32, an estimation on how the risk will change for the dummy non-life company for the four different scenarios can be obtained by scaling the flood SCR values of each country. The Gross nat cat SCR for the EEA for flood is equal to ~10 million.

	Baseline	RCP 2.6	RCP 8.5
2020	11.5	na	na
2030	na	12	13
2040	na	14	18

Table 33: Estimated Gross SCR (in million EUR) for the different scenarios.

It would then for example be possible to use the changes in SCR and analyse how the solvency ratio might be impacted for example. These changes in Gross SCR could also impact the need to modify the reinsurance structure.

Elements to consider when using the NGFS Climate impact explorer

When using the Climate explorer it is important to consider the following points:

- Usage: the explorer is very easy to use and open source;
- Time horizon: the explorer allows to get access to various time horizons;
- RCP scenarios: various RCP scenarios are available which allow to look at different warming scenarios as mentioned in the Opinion;
- Geographical resolution: the explorer does provide a view for different European countries as well as regional views for certain parameters. Unfortunately, this was not available at the time this application guidance was written. It would be important to consider more detailed geographical granularity of the analysis when the data will be available;
- Annual damage versus SCR: annual damages are available in the explorer. In the analysis, the changes on the annual damages to scale the SCR values were used. This is not 100% accurate as the changes in the 200 RP loss might be different compared to the annual damages;
- Projection of future economy: currently the results shown by the NGFS do not project future economies;
- Modelling the right exposure: the changes in annual damages shown in the explorer are based on a total exposure which might be significantly different from the individual insurer exposure.

Using Peseta IV

The PESETA IV[39] study aims to better understand the effects of climate change on Europe, for a number of climate change impact sectors, and how these effects could be avoided with mitigation and adaptation policies.

Input needed for running the analysis

Input data	Tool/Method
SCR by location per peril	Peseta IV

Scenario narrative

The following scenarios are considered:

- Scenario 2 - RCP 4.5 and time horizon = 2050: consider a time horizon of 30 years and a warming scenario where increase remains below 2°C (at the end of the century);
- Scenario 4 - RCP 8.5 and time horizon = 2050: consider a time horizon of 30 years and a warming scenario above 2°C (at the end of the century);

It is unfortunately not possible to show a scenario for a shorter time horizon as the data are not available in the Peseta IV study.

Physical risks

The study provides changes in annual damages for river floods if a warming scenario of 1.5°C and 2°C are considered by mid-century. The study considers also projection from future economies.

[39] JRC PESETA IV | EU Science Hub (europa.eu)

		EAD Economy 2050	
Country	**base**	**1.5°C**	**2.0°C**
Austria	262	523	603
Belgium	212	494	707
Bulgaria	83	141	179
Croatia	176	263	369
Cyprus	4	5	5
Czechia	405	755	947
Denmark	14	23	30
Estonia	53	44	48
Finland	252	383	558
France	1283	3048	4432
Germany	922	2052	2870
Greece	74	79	106
Hungary	260	618	905
Ireland	60	117	156
Italy	847	1550	1922
Latvia	211	345	439
Lithuania	106	144	169
Luxembourg	19	41	60
Malta	NA	NA	NA
Netherlands	79	201	393
Poland	571	1115	1411
Portugal	53	51	52
Romania	341	573	762
Slovakia	144	312	391
Slovenia	56	111	153
Spain	451	679	718
Sweden	228	582	1068
UK	642	1358	1818
EU+UK	**7,809**	**15609**	**21268**

Table 34: Expected annual economic damage in million EUR foreseen for the 2050 economy and society. The 1.5°C and 2°C warming scenarios in 2050 are considered (JRC, 2020).

Loss estimation

The changes observed at country level between expected annual damages for the baseline and warming scenarios for the 2050 economy (as shown in Table 34 above) to scale the flood of the dummy portfolio per country will be used. By doing this a flood SCR for the 2050 economy under a 1.5°C scenario in 2050 equal to ~20 million and a flood SCR for the 2050 economy under a 2°C scenario in 2050 equal to ~28 million are estimated.

Scaling factor 1.5°C scenario in 2050	Scaling factor 2°C scenario in 2050	Scaled SCR 1.5°C scenario in 2050	Scaled SCR 2°C scenario in 2050
2.22	3.11	15.4	21.6

Table 35: Example for Germany (SCR in million EUR).

Elements to consider when using Peseta IV

When using Peseta IV it is important to consider the following points:

- Usage: study is open source.
- Time horizon: only two time horizons are available by 2050 and 2100.
- RCP scenarios: various RCP scenarios are available which allow to look at different warming scenarios as mentioned in the Opinion;
- Geographical resolution: the changes in risks are available at country level and could even be retrieved at regional level (NUTS 2).
- Annual damage versus SCR: expected annual economic damage are available in the study. In the analysis, the changes on the annual damages to scale the SCR values were used. This is not 100% accurate as the changes in the 200 RP loss might be different compared to the annual damages;
- Projection of future economies: the study includes the view from different future economies;
- Modelling the right exposure: the changes in expected annual economic damages shown in the study are based on a total exposure which might be significantly different from the individual insurer exposure.

Using cat models

Catastrophe modeling is the practice of using computer programs to mathematically represent the physical characteristics of natural catastrophes, terrorism, pandemics, extreme casualty events, and cyber incidents[40]. These models can also be used to better understand the impact of climate change.

[40] Catastrophe Modeling | AIR Worldwide (air-worldwide.com)

Input needed for running the analysis

Input data	Tool/Method
Sum insured by location (ideally per asset) per peril	Cat model

Scenario narrative

- Scenario 1 - RCP 2.6 and a time horizon = 2030: consider a time horizon of 10 years and a warming scenario which below the 2°C (at the end of the century);
- Scenario 2 - RCP 2.6 and time horizon = 2050: consider a time horizon of 30 years and a warming scenario which is below the 2°C (at the end of the century);
- Scenario 3 - RCP 8.5 and time horizon = 2030: consider a time horizon of 10 years and a warming scenario above 2°C (at the end of the century);
- Scenario 4 - RCP 8.5 and time horizon = 2050: consider a time horizon of 30 years and a warming scenario above 2°C (at the end of the century);

Physical risks

The analysis is done using the RMS European Flood (baseline) and RMS European Flood Climate Change models. The sub-perils include pluvial and fluvial risks. Results are for Gross Loss, including post-loss amplification.

The recent study published by RMS (2021) sheds light on the likely magnitude of changes in flood risk for the European insurance sector. The EURO-CORDEX[41] simulated changes in daily maximum rainfall were used to adjust the riverine and pluvial-flood cat model in order to estimate the

[41] In line with similar study on future precipitation patterns in Europe, EURO-CORDEX results project an increase in extreme rainfall most of the year in Northern and Central Europe. For further details, please see: https://euro-cordex.net/index.php.en.

expected changes in losses for (re)insurance undertakings under different Representative Concentration Pathway (RCP) scenarios and time horizons.

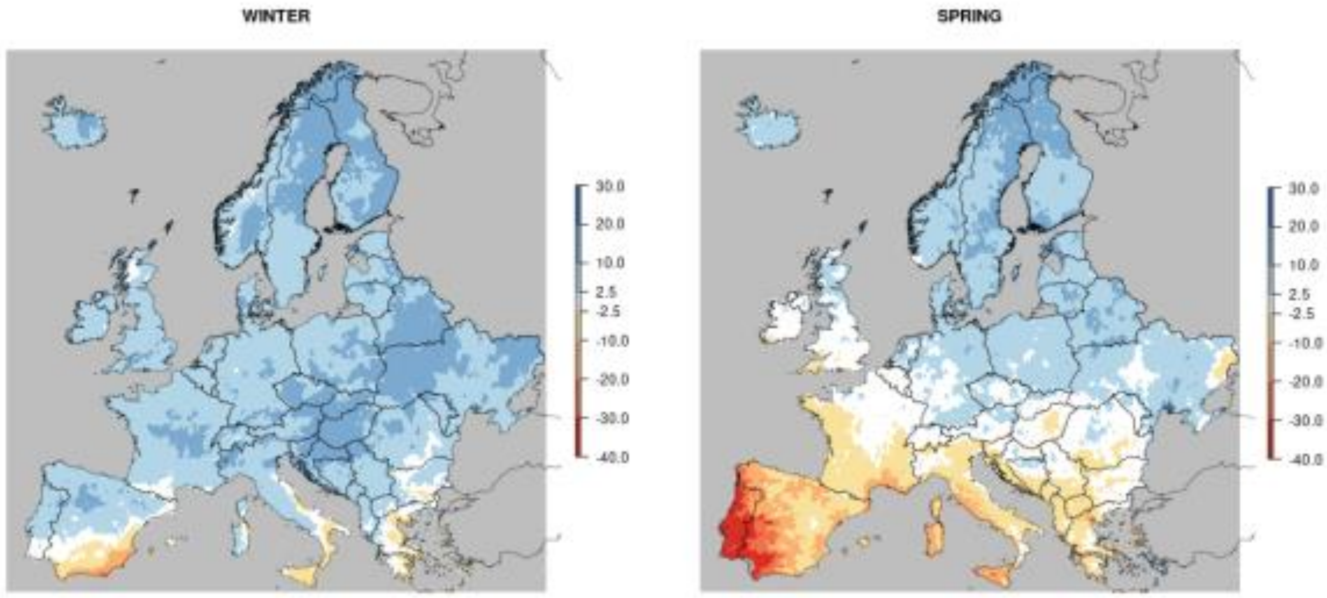


Figure 43: Projected percentage change in seasonal precipitation based on EURO-CORDEX data by 2041-2070 relative to the base period 1981-2010 under RCP 4.5 (RMS, 2021).

Loss estimation

The cat model estimates the losses for the baseline and the four different scenarios. When using cat models, it is possible to directly enter the dummy non-life company exposure[42].

The relative changes in the table below show how the different RPL changes compared to the relative baseline for the occurrence exceedance probability (OEP)[43] for different RP and for the four

[42] In this specific example, the exposure used stems from the RMS European Flood Insured Exposure Database (2020 vintage), which has then subsampled from to represent the concentrations of the dummy non-life company. This subsampling includes some regionalization within each country, rather than just a straight scaling of the countrywide exposure, to give a national "synthetic" portfolio. In a real case scenario, undertakings should directly enter their own exposure.

[43] The OEP is the probability that the associated loss level will be exceeded by any event in any given year.

defined scenarios. Figure 46 provides the country level annual changes in aggregated annual losses[44].

OEP	*Relative Change from Baseline*			
	r26_2030	r26_2050	r85_2030	r85_2050
20	10-20%	20-30%	20-30%	60-80%
50	10-20%	20-30%	20-30%	> 80%
75	10-20%	20-30%	20-30%	> 80%
100	10-20%	20-30%	20-30%	> 80%
150	10-20%	20-30%	20-30%	> 80%
200	10-20%	20-30%	20-30%	60-80%
250	10-20%	20-30%	20-30%	60-80%
300	10-20%	20-30%	20-30%	40-60%
400	10-20%	10-20%	20-30%	40-60%
500	< 10%	10-20%	10-20%	40-60%
AAL	10-20%	20-30%	20-30%	60-80%

Table 36: Relative OEP changes from baseline for scenarios 1 to 4 (see above).

[44] These results could also be obtained at a more granular level (regions, per asset) from a cat model.

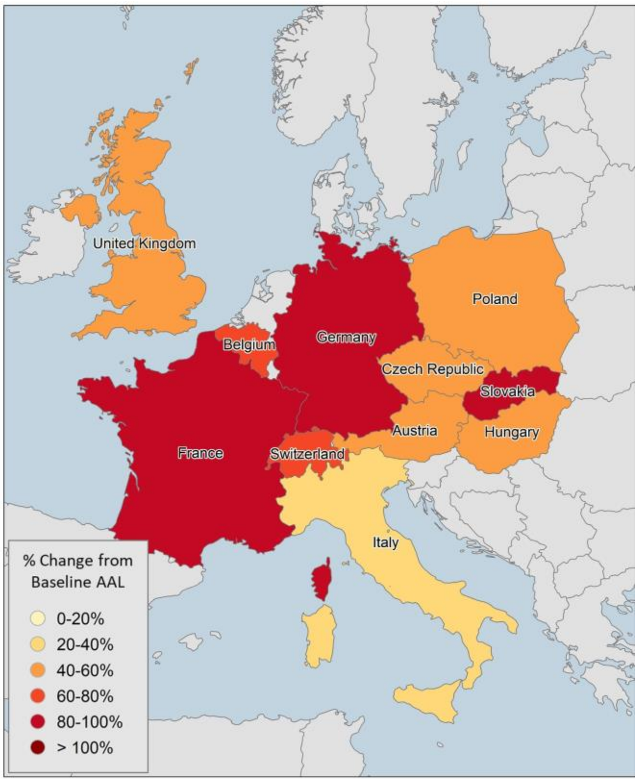


Figure 44: Country-level change in AAL vs baseline for the portfolio, RCP8.5 in 2050.

The below tables shows how the dummy non-life SCR will change for the different scenarios.

	RCP 2.6	RCP 8.5
2030	11.45	12.45
2050	12.77	17.64

Table 37: Estimated Gross OEP SCR (in million EUR) for the four different scenarios.

Elements to consider when using cat models

When using cat models it is important to consider the following points:

- Usage: most of the cat models are commercial models. It will therefore not be possible to get access to the results without paying for a license;
- Time horizon: cat models allow to get access to various time horizons;

- RCP scenarios: various RCP scenarios are available which allow to look at different warming scenarios as mentioned in the Opinion;
- Geographical resolution: cat models can allow for a very detailed modelling (per asset). Results in the below analysis are shown for on a country-wide basis, although both the climate-conditioning method and loss-analytics engine operate at higher levels of granularity, such that loss changes at higher resolutions can also be obtained depending on the use-case (e.g. postal-code loss impacts). The loss calculation also depends on exactly where the exposures are located, industry-wide impacts will differ to those shown here.
- Annual damage versus SCR: cat models can calculate both annual damages but also provide losses for different return periods;
- Future economies: the cat models would not necessarily include views on future economies. It would be up to the user to scale the inputs accordingly;
- Modelling the right exposure: it is possible to directly use the undertaking own exposure as a cat model input. This allows for a proper modelling of the risk.

Using existing stress tests

Previous scenarios, stress tests (FSI, 2021) could also be used to perform a climate change scenario analysis in the ORSA. The UK PRA has for example launched its biennial insurance stress test in 2019 which included an exploratory exercise in relation to cyber underwriting and climate change (PRA, 2019b). The dummy non-life company will explore if this could be helpful to conduct a scenario analysis for its ORSA.

<u>Input needed for running the analysis</u>

Input data	Tool/Method
SCR by location per peril	Existing stress tests

Scenario narrative

- Scenario A - A sudden transition (a Minsky moment2), ensuing from rapid global action and policies, and materialising over the medium-term business planning horizon that results in achieving a temperature increase being kept below 2 °C (relative to pre-industrial levels) but only following a disorderly transition. In this scenario, transition risk is maximised. The scenario is based on the type of disorderly transitions highlighted the IPCC Fifth Assessment Report (2014). [Shock parameters illustrative of potential impact in 2022];

- Scenario B - A long-term orderly transition scenario that is broadly in line with the Paris Agreement. This involves a maximum temperature increase being kept well below 2 °C (relative to pre-industrial levels) with the economy transitioning in the next three decades to achieve carbon neutrality by 2050 and greenhouse-gas neutrality in the decades thereafter. The underlying assumptions for this Scenario are based on the scenarios assessed in the IPCC Special Report on Global Warming of 1.5°C (2018)4 . [Shock parameters illustrative of potential impact in 2050];
- Scenario C - A scenario with failed future improvements in climate policy, reaching a temperature increase in excess of 4°C (relative to pre-industrial levels) by 2100 assuming no transition and a continuation of current policy trends. Physical climate change is high under this scenario, with climate impacts for these emissions reflecting the riskier (high) end of current estimates. [Shock parameters illustrative of potential impact in 2100];

Physical risks

The PRA stress test (PRA, 2019b) provides factors to assess the potential impact on the Annual Average Loss and potential changes to the 1-in-100 Aggregate Exceedance Probability for all insurance contracts that could give rise to a claim from natural catastrophes in the UK and the US (Table 38 shows the parameters for the UK).

		Transition Risks			Physical Risks		
Sector	Assumptions	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
UK weather exposed LoBs- flood[1], freeze and subsidence[1]	% increase in surface run-off resulting from increased precipitation (cumecs)				5%	10%	40%
	Uniform increase in cm in average storm tide sea-levels for UK mainland coastline.				2cm	10cm	50cm
	Increase in frequency of subsidence-related property claims using as a benchmark the worst year on record				3%	7%	15%
	Increase in frequency of freeze-related property claims using as a benchmark the worst year on record				5%	20%	40%

Table 38: Impacts to liabilities from physical risk for General Insurers.

The parameters provided by the PRA stress test are for the UK and the US. The dummy non-life company has only very little exposure in the UK and no exposure in the US. The analysis will therefore not be complete.

The physical parameters provided are made for sea-level rise, subsidence, freeze and increased precipitations. The dummy non-life company does not provide any coverage for subsidence, freeze and sea-level rise. The only parameter which could be used to make a loss estimation is the increase in surface run-off resulting from increased precipitation.

Loss estimation

In order to make a loss estimation from the changes in increase in surface run-off, a cat model would be necessary. For example, some cat model vendors modified the necessary models for their clients[45]. They provided their clients with industrywide factors, which allowed for the approximation of losses under the PRA assumptions but will likely not accurately reflect the impact on specific portfolios. For this reason, cat model vendors also suggested to run (re)insurers' own exposures through the adjusted models. Taken the fact that the parameters are just available for the UK, the dummy non-life company decided to not continue with this analysis.

Elements to consider when using existing stress tests

When using existing stress test, it is important to consider the following points:

- Usage: existing stress tests might not always be fit for purpose as they are developed for specific national conditions for example. However the parameters are available as open source and could be used if relevant for the undertakings' exposure;
- Time horizon: the time horizon are pre-defined in the stress tests it might therefore not necessarily fit the need of the undertakings;
- RCP scenarios: various RCP scenarios are usually available which allow to look at different warming scenarios as mentioned in the Opinion;
- Geographical resolution: detailed parameters at various geographical resolution might not be available. For the example above, data were only provided at country level;
- Annual damage versus SCR: in the considered stress test, factors to assess the potential impact on average Loss and potential changes to the 1-in-100 Aggregate Exceedance Probability were provided. This might not necessarily be fit for purpose if the undertaking wants to consider other RP;
- Future economies: the parameters provided in the stress test do not capture future economies;
- Modelling the right exposure: some parameters are provided as changes of the physical risk (increase of surface run-off) where a cat model would be required to estimate the potential financial losses. In this case, the undertaking exposure could be modelled. Some parameters

[45] Today's stress test for tomorrow's climate (rms.com)

provided (changes in claims frequency) also would not require the need of a additional cat model but would also not reflect the specificities of each undertaking's portfolio.

CLIMATE CHANGE SCENARIO ANALYSIS FOR THE DUMMY LIFE COMPANY

Stress testing for climate change is different from existing traditional insurance stress testing due to both the parameters involved (e.g. emissions , climate policy, technology, changes in temperature) and still subject to high uncertainty and a strong academic debate.

Data and methodologies might strongly differ with respect to the existing models and climate risk models might require insurers to rethink and restructure their data system or alternatively, make use of specialized external data providers.

What follows are three examples of potential scenario analyses for insurance undertakings, using three different approaches:

- Using a combined climate risk scenario: this method aims at leveraging on more traditional stress tests used in the ORSA reports, which often assume a comparison between a baseline Solvency II evaluation and a shocked evaluation under a modified scenario, where some relevant parameters are shocked;
- Using advanced sectoral-specific information: PACTA offers the possibility to investigate climate risk variables related to the usage of power and CO2 emissions of the Investment portfolio, providing the user with a technical and granular analysis;
- Using macro-economic variables applied to insurers: the third stress test is an overview of the ACPR (2021) work "A first assessment of financial risks stemming from climate change" where macroeconomic variables are applied to real insurers.

Adapting traditional techniques to climate change

Scenario narrative

An important aspect of scenario analysis concerns the question whether the risk factors should be combined into one scenario. Depending on the risk drivers identified in the materiality assessment, the scenario can take the form of:

- **Single risk factor**: the shock concerns a specific asset or insurance risk factor, e.g. : transition shock causing a drop of impacted Equity by X% or decrease of life expectancy due to chronic physical risk by X%;

- **Single scenario**: multiple risk factors but limited to a specific area of shock, i.e. only asset or liabilities shocks;

- **Combined scenario**: multiple risk factors affecting both assets and liabilities, e.g. transition shock on assets and physical risk on assets and liabilities.

The choice of the scenario above should be influenced by the outcome of the materiality assessment. Single risk factor shocks could fit an undertaking holding a concentrated exposure to climate risk in a specific asset class while the combined scenarios should be chosen when multiple material risk drivers have been identified in the materiality assessment.

Transition / Physical risks

One of the challenges of including climate risk scenarios in traditional scenario analysis frameworks concerns the time horizon. The impacts of climate change scenarios are expected to manifest themselves fully only over a considerable period, beyond the time horizon typically used for ORSA scenario analysis (3-5 years).

When an actuarial model is in place, the long term nature of life insurance liabilities allows to potentially include the long term expectations on the impact of climate change into the projections underlying the solvency calculations.

Examples of possible shocks might be, based on the materiality assessment of the dummy company previously described:

- Market value of equity invested in sectors identified as sensitive to transition risk – short/long term;
- Market value of property invested in region with high physical risk – medium / long term;

- Corporate bonds' spread for investments in sectors identified as sensitive to transition risk – short/long term;

- Mortality rates and related life claims in the long term due to physical risk drivers – long term;

- Lapses / new business as a conquence of damages to reputation for failing to mitigate transition risk – Short / Long term.

The calibration of the shocks could be based on expert judgement principles, backed by relevant and updated studies, or on existing stress tests which already tried to quantify the impact of transition risk on the assets, such as “Sensitivity analysis of climate-change related transition risk” (EIOPA, 2020). The same approach can be used to estimate the increase in the level of other variables, such as mortality rates / lapses.

Probably, the most material risk for traditional life insurance companies is transition risk, whose occurrence is certain but its timing is uncertain. Models might aim at capturing it via either an instantaneous or a “late and sudden shock”. While the former is a shock applied at t=0, the latter materializes at a later stage, e.g. 3-5 years.

Loss estimation

The methodology for the estimation of the loss will depend on the metrics chosen for the analysis. A typical metrics for such an exercise is the Solvency ratio but other alternatives could be chosen.

The impact of the combined climate stress test might be measured via a comparison between the results of baseline and stressed scenario.

Elements to consider

- Usage: the traditional solvency framework for scenario analysis might not always be fit for purpose as it does not important variables (e.g. emissions, climate policy, technology, changes in temperature). Other approaches to measure climate change might be preferable.
- Time horizon: The impacts of climate change scenarios are expected to manifest themselves fully only over a considerable period, beyond the time horizon normally used in the traditional ORSA projections;
- Geographical resolution: the geographical location of the impacted investment can be obtained by the list of investments;
- Future economies: the parameters provided in the stress test do not capture future economies. Additional assumptions about inflation and GDP growth might be implemented in the model;
- Modelling the right exposure: the granularity of the shock should be consistent with the materiality assessment, which might present some limitations due to e.g. lack of data.

Using PACTA

Scenario narrative

PACTA scenarios measure the alignment of a portfolio to a range of climate transition scenarios via forward-looking comparisons of key outputs. The modules currently available focus on production trajectories, current and future technology deployed and emissions intensity of the current portfolio.

Transition risks

Production trajectories

This scenario is based on the production plans of the companies in the selected portfolio. The projection is based on granular technology decarbonisation roadmaps applied to the sectors power, coal and oil and gas, automotive and results are compared against the production trajectory of a given index benchmark.

This scenario offers a very high degree of customization. The parameters to select are:

- Asset Class (either equity or corporate bonds);
- Technology (e.g. coal power, gas power, hydro power, nuclear power, electric automotive and several others);
- Benchmark (for now four benchmarks are available);
- Scenario geography;
- Scenario source.

The chart below is an example of an output of this scenario analysis performed with the dummy portfolio, where only one exposure is considered affected by transition risk. It pictures the coal power in the equity exposure of the dummy life company with one of the possible settings of the scenario. The different colored sections refer to the coal power production in line with the different climate scenario.

The dashed line represents the coal power production of the benchmark while the solid line represents the coal power production of the equity exposure. In this case, the outcome is quite positive because the equity investment of the dummy life company plans a higher drop in the production of coal power than the benchmark.

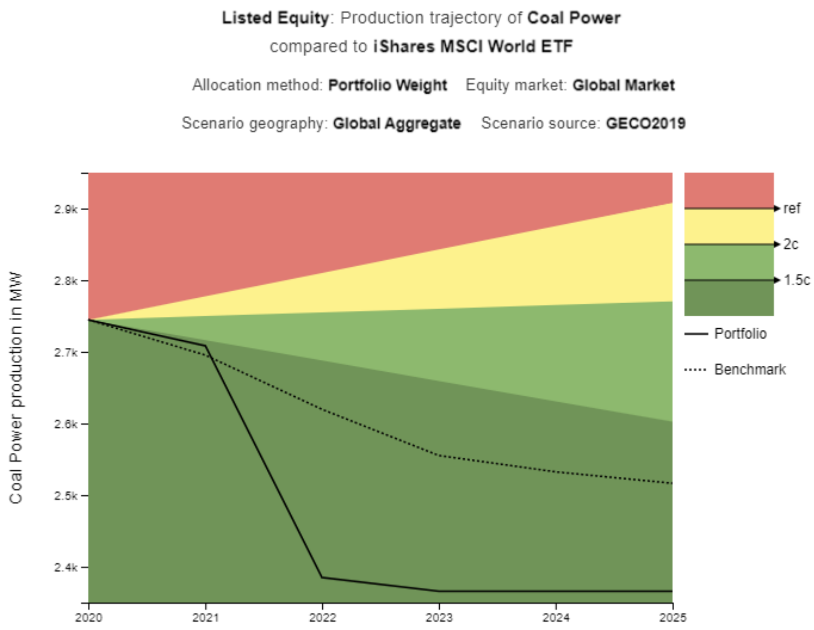


Figure 45: Production trajectory of Coal Power.

For the corporate bonds scenario analysis the setting above will be changes and the focus will be on the gas power, while the scenario used for the analysis will refer to those set in the World Energy Outlook 2019. In the chart below, the SDS line corresponds to the "Sustainable development scenario", in line with the Paris agreement. The upper red-colored section represents the "Current Policies Scenario" which would imply the business to continue as usual, without meeting the reduction in the emissions requested by the Paris agreement.

While the benchmark selected performs in line with the expectations of the SDS scenario (dashed line) the production plans underlying the corporate bonds portfolio underlie a concerning deviation for the gas power which the company might want to address.

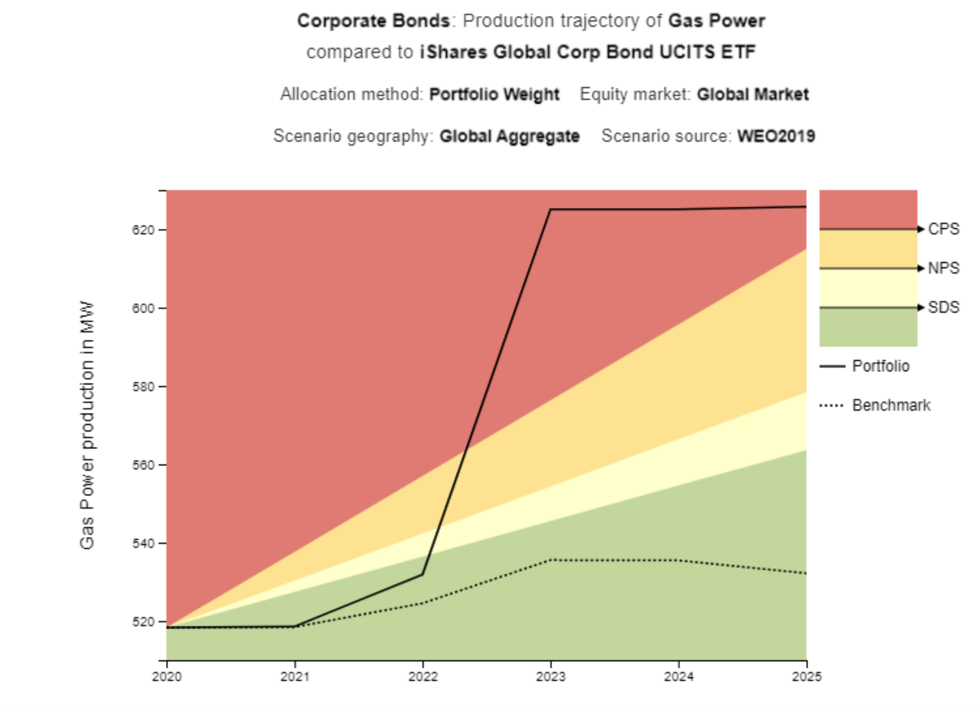


Figure 46: Production trajectory of Gas power.

The same analysis above can be replicated for different technology and the results would highlight the intensity of the deviations and give to the management the tools to try to identify and properly monitor / mitigate the underlying risk or production excess.

Future technology breakdown

The PACTA tool also provides the split between technologies in 5-years time, which is the latest projection year available in the CAPEX plans underlying the PACTA's calculations. It is possible to tailor the output of the scenario analysis even though the projections don't take into account changes in the Asset allocation.

As a mere example, the following chart compares:

- The expected technology mix of the current portfolio in 5 years;
- The technology mix the companies in the portfolio should have in order to meet the scenario target (which in this case is based on GECO 2019);
- The technology mix the companies in the selected benchmark portfolio should have in order to meet the scenario target (GECO 2019).

The equity exposure of the dummy life company shows a satisfactory outcome, with the 5-years estimate almost in line with the aligned portfolio, which is characterized by an only slightly higher presence of low-carbon technologies.

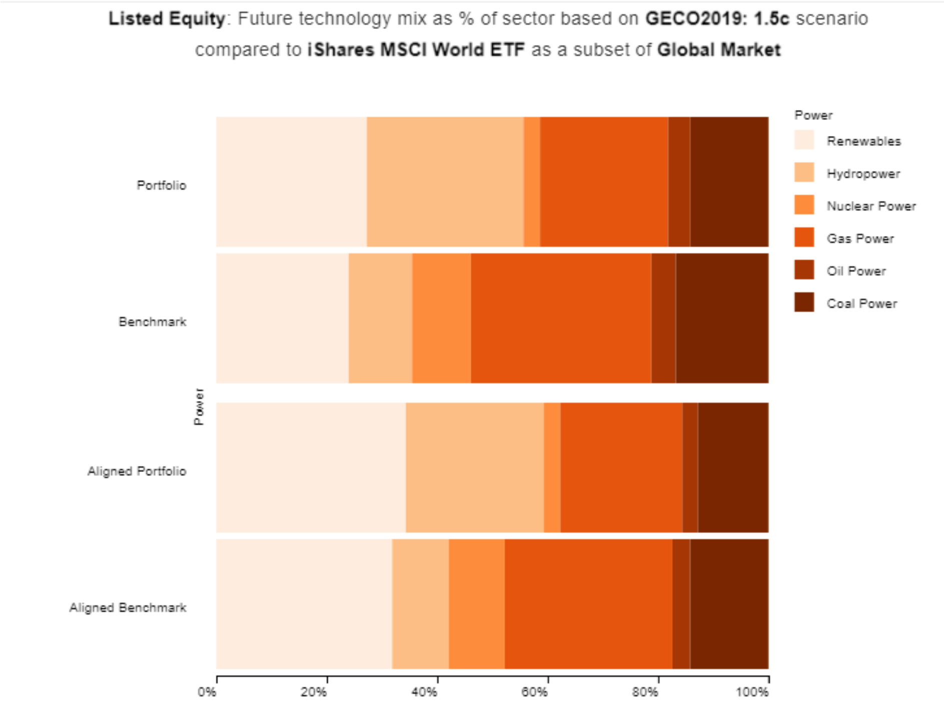


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Figure 47: Future technology mix – Listed equity.

For corporate bonds the same breakdown is provided using a different benchmark and reference scenario. In terms of technology mix the corporate bonds investments seem to perform better than the benchmark selected, both in current and forward-looking perspective. The management actions expected to take place in the next five years would be expected to further contribute to this trend.

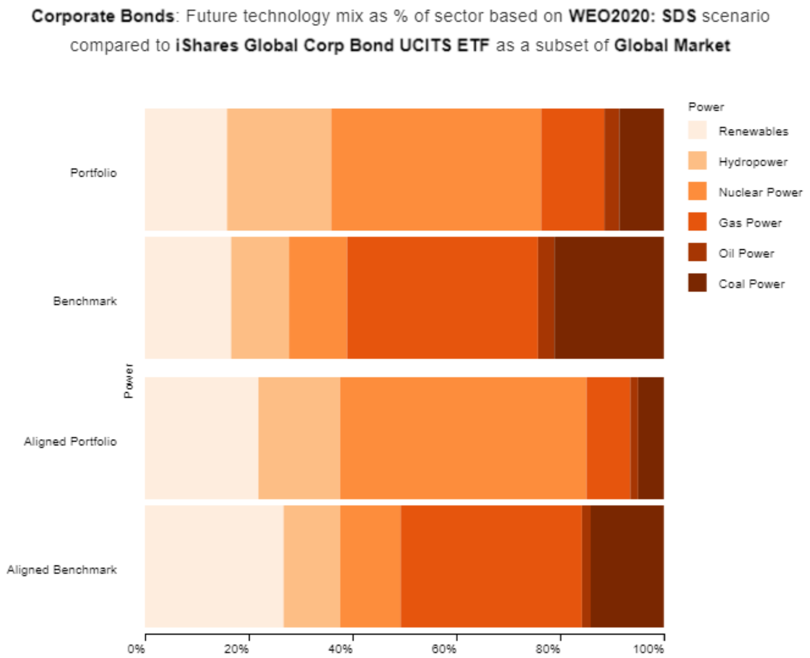

Figure 48: Future technology mix – corporate bonds.

Loss estimation

The final output of the PACTA exercise is the estimation of a loss on asset for equity and bonds.

The bar below is split into three sections:

- The assets not analysed, as not considered climate related, before and after the transition scenario;
- The assets climate related, before and after the transition scenario;
- The expected loss, computed as a difference between the stressed asset value and the baseline initial asset value. It is possible to tailor the exercise by selecting between two different transition scenarios.

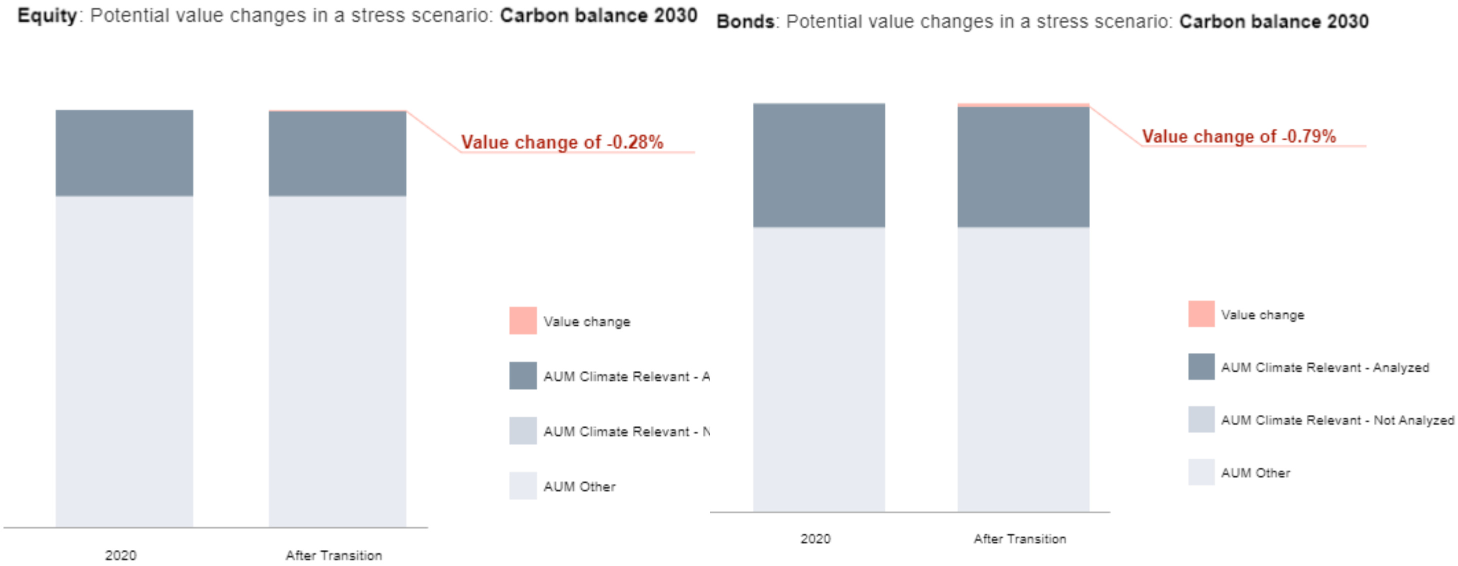

Figure 49: Loss estimation for equity and corporate bonds.

Elements to consider

PACTA focuses on the impact on the Assets side while the solvency of insurance companies depends on the interaction between assets and liabilities. The impact of the liabilities will have to be considered, e.g. via a proxy which takes into account the peculiarities and the internal experience of the insurer.

- Usage: the online tool offers a wide set of environmental variables (e.g. emissions, climate policy, technology, changes in temperature) and would surely be an interesting tool to use. Its main limitations would be the lack of impact on the liabilities which would strongly depend on the products portfolio of the undertaking. In addition, the online tool might raise confidentiality issues in the upload of the portfolio in the open-source software as well as increase the operational risk associated with the use of external providers of scenario and data;
- Time horizon: the time horizon of the projection is 5 years, consistently with the CAPEX plans used as inputs. This might be a short time horizon for a climate risk stress test;
- Scenarios: PACTA offers the possibility of selecting between a large set of possible scenarios;
- Geographical resolution: It is provided as one of the outputs by the software itself;
- Future economies: the parameters provided in the stress test do not capture future economies;

- Modelling the right exposure: PACTA allows for detailed analysis of the portfolio uploaded

Using existing climate change scenario

The 2020-2021 ACPR pilot climate exercise scenarios is an example of an application of a stress test to a whole market.

Scenarios were designed using the high-level NGFS scenarios[46] as a conceptual starting point. The first representative scenario used in this exercise was an "orderly" transition, in which an ecological transition starts as early as 2020 via the introduction of proactive mitigation measures represented by a significant increase in carbon prices. At the French national level, this corresponds to the narrative of the so-called National Low Carbon Strategy (SNBC), which consists of a roadmap to comply with the Paris Agreement commitments of carbon neutrality by 2050 and limit the rise of temperatures to below 2°C. As this is the baseline or reference scenario, the structural transformation of the economy is announced, anticipated, and indeed manifests without any major macroeconomic perturbations.

Scenario narrative

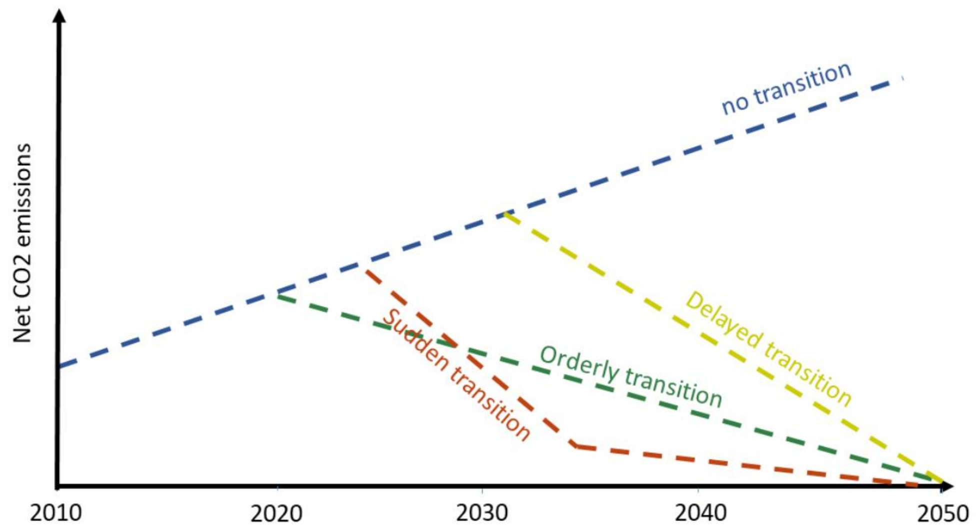

Figure 50: NGFS scenarios.

[46] The four identified NGFS scenario categories—orderly, disorderly, "hot house world" and "too little too late"—are based on the estimates produced by scientific institutions participating in the works of the International Panel on Climate Change (IPCC). Projections of global greenhouse gas emissions rely on both integrated assessment modelling (IAM) as well as assumptions on the compliance with commitments made by countries to address climate change.

Two disorderly variant scenarios are also considered, in contrast to the baseline described above: an accelerated or "swift" transition and a delayed transition. These scenarios assume that the targets for reducing greenhouse gas emissions are not met by 2025 and 2030 respectively, which calls for the implementation of more proactive (and economically disruptive) measures. Both scenarios exactly replicate the aggregate level emission, carbon price and GDP trajectories of the representative scenario for a "disorderly" transition published by the NGFS in June 2020.

Transition risks

The delayed transition calls for an increase in the carbon prices from $14 per ton of CO2 globally in 2030 to $704 in 2050. This increase is reflected in a series of shocks to various industries and leads to a very strong increase in real energy prices (+125%) over the period for France. The second adverse scenario—the accelerated transition—combines an even sharper increase in the price of carbon, which reaches $917 per ton of CO2 in 2050, as well as a less favorable evolution of productivity from 2025 onwards.

Macroeconomic variables as well as sectoral shocks were projected using a suite of different econometric or financial models[47].

Loss estimation

The narrative underlying the ACPR transition-risk stress factors ultimately imply an instantaneous shock, as discussed above. Indeed, in 2025 for the accelerated transition variant (and 2030 for the delayed variant), the above scenarios assume that information is revealed to financial markets which allow them to anticipate the future macro-financial consequences resulting from each scenario. Concretely, a trend is provided to insurers with respect to future dividend or coupon payments on financial instruments—allowing for multi-period balance sheet projection through 2050—and a one-time parallel shift is applied to this trajectory following the public policy (carbon tax) shocks in the respective scenarios.

The multi-period framework of the ACPR exercise first involves a 5-year static balance sheet period (2020-2025) during which participants are unable to implement strategic management actions to help attenuate losses. The remainder of the exercise (2025-2050) represented the dynamic balance sheet phase. Examples of authorized management actions include a modification to reinsurance treaties, portfolio reallocation across sectors or asset classes, exit/entry across business lines or insurance contracts, premiums increases and geographic reallocations on the liability side.

[47] For details, see the Banque de France Working Paper, "Climate-Related Scenarios for Financial Stability Assessment: An Application to France" https://publications.banque-france.fr/en/climate-related-scenarios-financial-stability-assessment-application-france.

Elements to consider

A number of methodological questions were raised throughout this new pilot exercise:

- During the dynamic balance sheet phase, exit or entry into business lines was a permitted management action.
- As is typical for any bottom-up exercise, undertakings apply shocks to their own exposures using internal ALM models. Many existing models are capable of projecting balance sheet variables over five or ten years, however rarely are such tools able to handle 30 year time horizons using current configurations.
- A higher level of sectoral granularity (as regards the stress factors) helps to isolate those activities which most highly depend on carbon emissions. However, reporting of sectoral codes often includes inconsistencies (e.g., as to the level of detail reported across sectors). Further, shocks for sectors without an obvious vulnerability to an ecological transition represented only marginal impacts to insurers' portfolios. From a scenario design perspective, this was due to the fact that no assumptions were made regarding large-scale economic crises, and the subsequent lack of variation in GDP growth rates across scenarios. This approach runs counter to the "stresses" typically applied in a traditional stress-test, and emphasizes the difficulties of applying instantaneous climate shocks within a multi-period exercise.

Other existing stress tests exercise

The table below provides additional examples on Stress Test exercises provided by supervisors:

Authority	Link	Method	Type of risk	Time horizon	Scenarios	Balance sheet impact
Bank of England (i)	Link	Stress test (bottom-up)	Physical and transition risk	30 years, with 5 year reporting intervals	BUA, Early Policy Action, Late Policy Action	Asset and liabilities, based on impact on individual counterparties
Bank of England (ii)	Link	Stress test (bottom-up)	Physical and Transition risk	2100 (with evaluations at 2022 and 2050)		
Bank of France	Link	Stress test (bottom-up)	Physical and Transition risk	2020-2050 (reporting steps at 2025, 2030, 2035,	Transition: Orderly (baseline), delayed, accelerated Physical: RCP 8.5 (+4	55 sectors considered for asset-side transition shocks. CATNAT impacts (flood,

				2040, & 2050)	degrees by 2100)	marine submersion, droughts and cyclones) projected at the department level.
De Nederlandsche Bank (i)	Link	Stress test (top-down)	Transition risk	5-year	Four scenarios: (1) policy shock, (2) technology shock, (3) double shock and (4) confidence shock.	Analysis of how the asset-side exposures of Dutch banks, insurers and pension funds are affected in scenarios of a disruptive energy transition.
California Insurance Commissioner	Link	2°C scenario analysis	Physical and Transition risk			
EIOPA Sensitivity analysis 2020	Link	Sensitivity analysis (top-down)	Transition risk	2019-2030	Transition: A late and sudden policy shock; a supplementary scenario based on the IEA “Beyond 2 degrees” (B2DS) scenario	Price sensitivity of equity, corporate bonds and government bonds holdings

CONCLUSIONS

This paper provides initial guidance for undertakings to conduct analyses on climate change in the ORSA. As mentioned previously, the application guidance is not mandatory. The undertakings should also not restrict themselves to the aspects covered in this application guidance, e.g., due to specific portfolios, undertakings might want to explore other alternatives to look at climate change risks. In addition, there might be other tools and data available to perform the different analyses shown in this application guidance.

With the help of "dummy" companies, EIOPA illustrated examples on how to conduct materiality assessments and run scenario analyses. From these examples, a number of points have been identified to be considered:

- Granularity: ideally, climate change analysis should be performed with a high level of granularity (as for example the impact of climate change can be very local). However, it will be very challenging to find the right tools/data to support very granular data analysis. In addition, considering the uncertainty linked with these type of analysis, it could also be questionable if too detailed analyses would be fit for purpose.
- Availability of tools: when developing this application guidance, EIOPA has been looking for available data and tools. While more and more tools and data are available/developed, it is still challenging to get access to the right tools/data. Some tools might be available as open source but would also contain some limitations, which ultimately might not be fit for purpose due to fixed parameters for example. Some other tools might be more flexible but could also require licensing fees.
- Finding the right tools/data for the right analysis: a real challenge when developing this application guidance was to find the right data/tools for the analysis the user wanted to conduct. For example, even for running materiality assessment, it was not always possible to get access to data which would consider the correct time period or which would provide sufficient information to make conclusions on different perils (data are available for change in precipitation but it is not straightforward to make the link to the actual changes on the insurer portfolio).
- Predefined parameters versus own parameters: while it could be convenient to use pre-defined parameters to run a climate change scenario, these pre-defined scenario might not always be relevant for individual undertaking's exposure. Developing scenarios based on own parameters could be more challenging but would also ensure that the scenarios are fit for purpose.

LIST OF ABBREVIATIONS

BSCR – Basic Solvency Capital Requirement

CMPI - Coupled Model Intercomparison Project

CPRS – Climate Policy Relevant Sector

GCM - General Circulation Models

GWP – Gross Written Premium

ISIN - International Securities Identification Number

LoB – Lines of Business

NGFS – Network for Greening the Financial System

OEP - Occurrence Exceedance Probability

ORSA - Own Risk and Solvency Assessment

PACTA - Paris Agreement Capital Transition Assessment

QRT – Quantitative Reporting Templates

RCP - Representative Concentration Pathway

RP – Return Period

RPL – Return Period Loss

SCR – Solvency Capital Requirement

TP - Technical provision

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ANNEX

ANNEX 1: DESCRIPTION OF THE DUMMY NON-LIFE COMPANY

Using the Quantitative Reporting Templates ("QRTs") the natural catastrophe risk amount broken down into perils for all solo undertakings which use standard formula in all countries was extracted.

The Earthquake peril has not been considered as the impact of climate change is expected to be minimal/inexistent. The natural catastrophe risk was then recalculated using the correlation matrix between the perils windstorm, flood, hail and subsidence.

For each undertaking the ratio between the natural catastrophe risk and the Basic Solvency Capital Requirement ("BSCR") was calculated to use as a proxy for the climate risk exposure.

Following data quality checks, the top 20 undertakings with the highest ratio were selected to be included in the dummy company. It is noted that small to medium sized undertakings were targeted and therefore the ones with a high Gross written premium were excluded. All values shown have been rounded.

Description of the dummy non-life company

The dummy non-life company is a small company with written premium of around 20m EUR mainly writing business in Fire and other damage to property and Motor. The company's assets comprise mainly of corporate bonds and equities as well as some deposits and cash.

A simplified balance sheet of the company is presented below:

Balance Sheet	Solvency Value
Property, plant & equipment held for own use	10.0
Investments (other than assets held for index-linked and unit-linked contracts)	26.9
Property (other than for own use)	0.5
Equities	13
Bonds	13.4
Government Bonds	2.0
Corporate Bonds	11.4
Other Assets	27.1
Total assets	**64.0**
Technical provisions – non-life	20.0
Other Liabilities	5.0

Total liabilities	**25.0**
Excess of assets over liabilities	39.0

Table 39: Market Value Balance Sheet in million EUR.

RISK PROFILE

The SCR of the dummy non-life company is driven by the non-life underwriting risk module (62%) which reflects the risk arising from the non-life insurance, the market risk (26%) as well as some counterparty default risk (12%). Since the dummy company is 100% non-life, there is no Life underwriting risk or Health underwriting risk and the non-life underwriting risk module has the highest proportion in the SCR as expected.

SCR Modules	%excl. diversification
Market risk	26%
Counterparty default risk	12%
Non-life underwriting risk	62%
SCR	100%

Table 40: SCR distribution across modules.

A breakdown of the non-life underwriting risk shows that it is driven primarily by the Non-life cat risk (71%), followed by the Non-life premium and reserve risk (25%) and Non-life lapse risk (4%).

Non-life underwriting risk	%incl. diversification
Non-life premium and reserve risk	25%
Non-life lapse risk	4%

Non-life catastrophe risk	71%
Total Non-Life underwriting risk	100%

Table 41: SCR distribution across non-life under risks.

UNDERWRITING PORTFOLIO

The underwriting portfolio of the dummy company is comprised of Fire and other damage to property (75%), Motor MTPL and Other (10%), General Liability (6%), Marine and Aviation (5%), and Income Protection insurance (4%).

LoB	Gross Written Premium	Weight %
Fire and other damage to property insurance	15.5	75%
General liability insurance	1.3	6%
Motor vehicle Liability Insurance	1	5%
Other motor insurance	1	5%
Marine, aviation and transport insurance	1	5%
Income Protection Insurance	0.8	4%
Total	20.6	100%

Table 42: Average premium per LoB in million EUR.

ANNEX 2: DESCRIPTION OF THE DUMMY LIFE COMPANY

The Investment mix presented in the figures below comes from the average of the five undertakings and will correspond to the one of the dummy company:

Asset Class	Weight
Corporate bonds	66.1%
Equity	12.7%
Government bonds	21.2%

Table 43: Investment mix of the Life company.

A simplified balance sheet of the company is presented below:

Balance Sheet	Solvency Value
Property, plant & equipment held for own use	6.2
Investments (other than assets held for index-linked and unit-linked contracts)	100.0
Equities	12.7
Bonds	87.3
Government Bonds	21.2
Corporate Bonds	66.1
Loans and mortgages	2.0
Cash and cash equivalents	7.6
Total assets	**115.8**
Technical provisions – With profit participation	88
Technical provisions – Other liabilities	5.5
Technical provisions – Unit / Index linked	1.2
Other Liabilities	3.5
Total liabilities	**98.2**
Excess of assets over liabilities	17.6

Table 44: Market Value Balance Sheet in million EUR.

The total value of Investment has been set to 100mn. The value for Property refer to an office building which the company uses for operational activities. The company has a few loans in place and holds a cash buffer in order to manage liquidity risk.

RISK PROFILE

The SCR of the dummy life company is driven by market risk, followed by Life underwriting risk and a little amount of counterparty.

SCR Modules	Weight
Market risk	60%
Counterparty default risk	12%
Life underwriting risk	28%
Solvency Capital Requirement	100%

Table 45: SCR distribution across modules.

A breakdown of the market risk see the dominance of equity, spread and interest rate risk due to the aggressive Asset allocation of the dummy life company. Currency and property are considered low and not material.

Market risk	Weight
Equity Risk	20%
Spread Risk	44%
Interest rate Risk	27%
Currency Risk	7%
Property Risk	2%
Total Market risk	100%

Table 46: SCR distribution across sub-modules.

UNDERWRITING PORTFOLIO

The underwriting business of the dummy company is based on “with profit participation products” (84%) with a minority of “other life products” (12%) which include “term life insurance products”. The company has recently included Unit / Linked products to their offer and the breakdown of the portfolio is as follows:

LoB	Gross Written Premium	Weight %
With profit participation products	12.5	84%
Unit / Index linked	0.7	4%
Other Life products	1.8	12%

Table 47: Gross Written premium per LoB in million EUR.

For the purposes of this analysis, EIOPA used insurers’ equity and corporate bond holdings from the List of Assets reported with the QRTs. The amount shown do not relate to any real undertaking and are just meant to be used as a mere example.

The assets portfolio is dominated by corporate bonds and equity, which might include transition risk depending on the intensity of the carbon activity of the issuer. The dummy life company also holds a portion of government bonds.

The equity portfolio counts only four different exposures, randomly selected among four well-known listed companies, diversified into Energy, Insurance, Hotel industry and Technology. This is due to data quality issues related to the real portfolio.

The corporate bonds portfolio is composed by over 50 financial instruments coming from the portfolios of the five selected undertakings after data quality adjustments such as removal of items lacking info on ISIN or the NACE Sector.

The amount of Collective Investment Undertakings has been considered not material for the companies selected and therefore excluded by the analysis. However, undertakings should apply a look-through approach in case of exposure to such instruments, as the identification of transition risk must be based on the underlying assets rather than on the assets / fund manager or issuer.

Loans have been excluded from this example as not material in the companies selected, but they might be relevant to analyze when the related counterparty exposure is considered to be material by the undertaking.

The small amount of assets related to Index or Unit Linked products has been excluded from the sample. However, it might be appropriate for the company to perform a specific assessment on them, particularly in case they include guarantees.

Finally, the total value of the investments has been set to 100 million EUR and the exposures in the Assets classes have been obtained by rescaling accordingly.

The following breakdown by rating of the corporate bonds portfolio mostly concentrated around BBB and A grade.

Rating	Weight
AAA	2%
AA	10%
AA+	0%
A+	0%
A	20%
A-	3%
BBB+	12%
BBB	29%
BBB-	17%
BB+	3%
BB	0%
BB-	3%
B+	1%
B-	0%
CCC+	0%

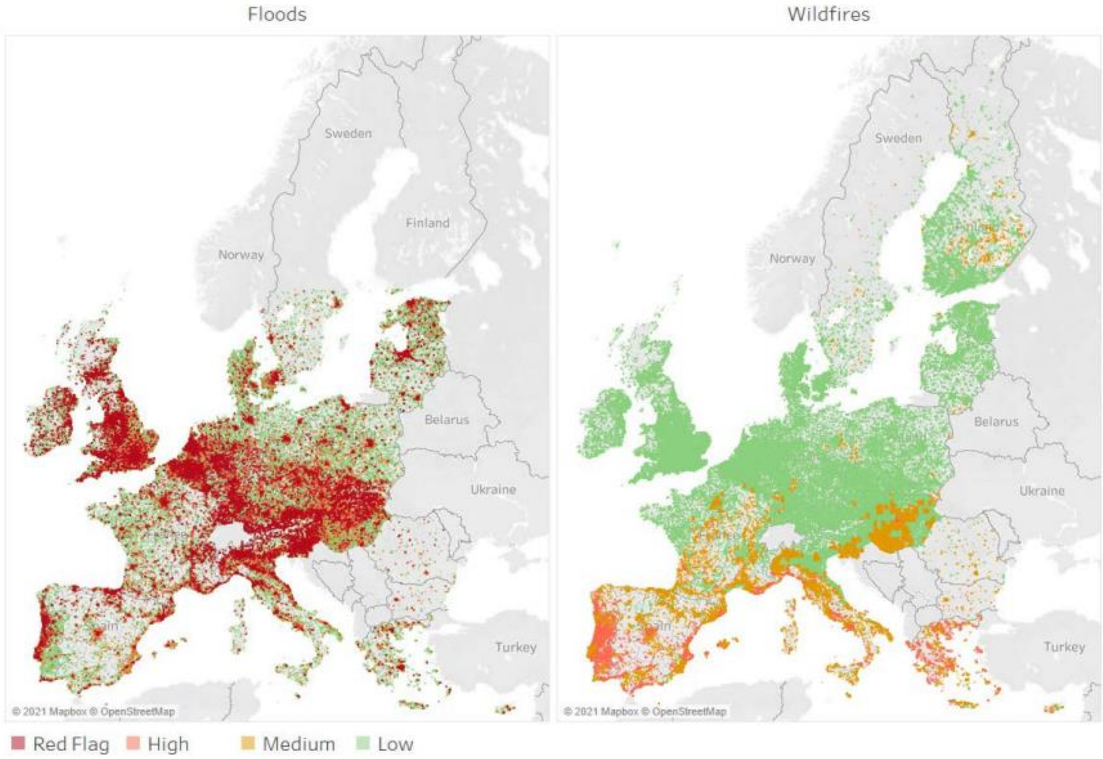
Table 48: Corporate bonds exposure by rating notches.

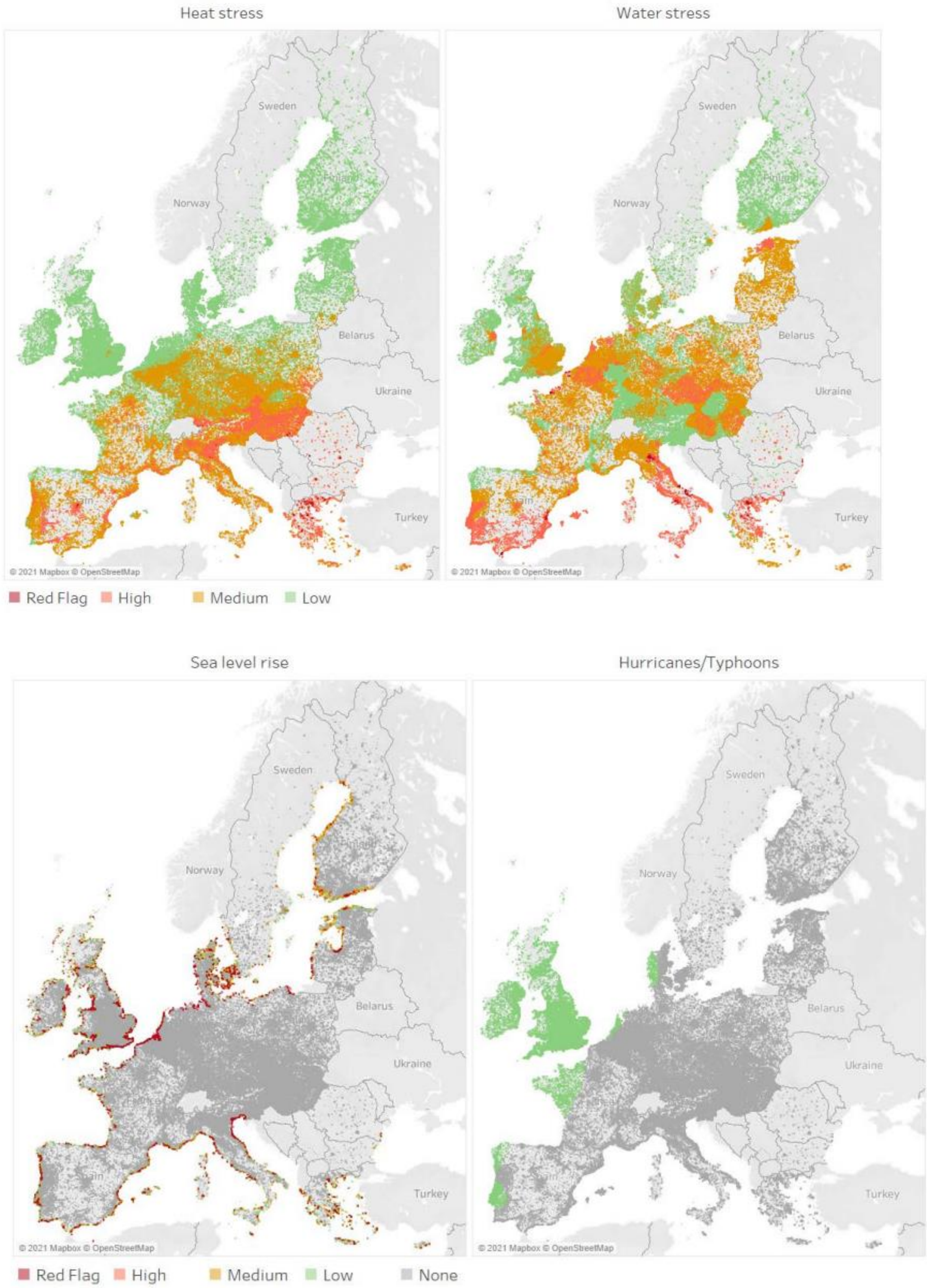
Liabilities

On the Liabilities side, the majority of the products refer to “with profit participation products” despite a low proportion of Unit Linked. However, Life companies might also hold in the portfolio Life products covering death and health which might have to be taken into account in the materiality assessment. Please refer to section “qualitative analysis “for further details.

ANNEX 3: EXPOSURE LEVELS TO INDIVIDUAL PHYSICAL HAZARDS FOR 1.5 MILLION FIRMS IN EUROPE

Source: Twenty four seven and ECB calculations (ECB/ESRB, 2021b).





Sources: Four Twenty Seven, ECB calculations. Notes: Firm exposure levels refer to those described in Section 1.2.3.

ANNEX 4: IMPACT ON TP

Climate change risk channel	Fire and other damage to property insurance	Miscellaneous financial loss	Other motor insurance	Marine, aviation and transport insurance
Physical risk	- Potential increase in frequency and severity of claims impacted by natural disasters. Examples include: - increased droughts leading to increased subsidence claims - increase in temperature impacting the frequency of wild fires - increase/decrease in freeze related claims - Increase in flooding events - The relevant increase will depend on the geographical location of the insured properties -Potential aggregations of risk and accumulations should be considered particularly in areas that become more prone to developing risks.	- Increases in number of claims under Property insurance could have infrastructure impacts and also lead to increased business interruption losses	- Potential increase in size of losses due to increased severe hailstorm events - Potential loss mitigation due to lower severity of cold winters - Increase in flooding events	- Under Marine/Aviation Hull insurance products, claims may increase over time due to increased hailstorm and lightning strikes

Climate change risk channel	Sub risk	Motor vehicle liability insurance	General Liability	Legal expenses/ Miscellaneous financial loss	Income protection insurance
Transition risk	**Legal**		Latent claims could emerge under products written on a losses occurring basis. Possible lawsuits arising from written exposures where the negative impact of carbon emissions is central to the	Losses emerging from third parties seeking compensation from the effects of climate change, e.g. companies	

			claim could increase, for example: - D&O: The insured person (director or officer) could be sued if they were unable to manage their company's impact or exposure to the effects of climate change - Professional Indemnity: Potential lawsuits could be expected especially in the construction industry which naturally can contribute to weather related risks through bad planning - Environmental liability: Flooding can lead to significant pollution and insureds could be at a risk of lawsuits - Aviation Liability: Could potentially face liability lawsuits over the perceived contribution of the industry to climate change	being sued because of the impact of their greenhouse gas emissions.	
	Technology/ Policy	- New and emerging technologies, i.e. electric/autonomous cars can result in increasing/decreasing claims as they could be more dangerous as it is more silent or safer due to the sensor mechanisms			With the transition to lower carbon economy, some companies could lose share value and as a result some employees might be made redundant. If these employees had previously taken Income protection insurance, then this could result in an increase of claims for this LoB.

Climate change risk channel	General implications on business model
Other risks to consider	-More frequent natural disasters will have a systemic effect on economics and cause market failures affecting both insurers and consumers - With the increase of the frequency and severity of claims and tail events, the insured risk can become very expensive and hence unaffordable for customers. Additionally reinsurance cover may become less accessible. This can result in premium loss which could lead to higher rates to compensate the business lost. This could mean lower rates of insurance penetration and a shrinking market for certain products/risks, i.e. coal related activities and exposed coastal properties -Insurers will have to adapt quickly and revise their policies and rearrange their portfolios based on the assessment of the evolving risks affecting their business model. The changes in frequency and severity will need to be modelled and allowed for in all aspects of the business - Climate change will increase uncertainty around reserves. Actuaries should consider whether their models take into account the trends for climate change before using them to estimate an ultimate claim figure and test how sensitive their models are to assumptions. Additionally, the interconnectivity of risk in terms of natural catastrophes, i.e. a flood after a hurricane should be considered in the assumptions - Whether any changes in response to climate change can impact future claim costs. These changes can be from the insurer’s side such as changes in underwriting practices or from the insured’s and the sector’s side such as changes in agriculture practices - Policy wordings and perils covered under each product should be analyzed to assess the insurer’s total exposure

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