

REPORT

on non-life underwriting and pricing in light of
climate change

EIOPA-BoS-21/259
01 July 2021



eiopa

European Insurance and
Occupational Pensions Authority

Table of Contents

Introduction	4
Background and context	4
Structure and purpose of the report	6
Non-life underwriting and pricing.....	8
Non-life underwriting and pricing in general.....	8
Non-life underwriting and pricing in the context of climate change.....	11
Annual re-pricing of short-term contracts in light of climate change	14
Options to ensure availability and affordability of insurance in light of climate change.....	18
Impact underwriting	18
Contribute to climate change adaptation or mitigation via risk-based pricing and contractual terms	22
Consider long-term insurance.....	26
Consider in underwriting strategy products and services contributing to climate change adaptation and mitigation	30
Annex: Case studies chosen by the insurance associations.....	39
Annex: Responses to the consultation paper	Error! Bookmark not defined.
Abbreviations.....	1
References	2

Introduction

Background and context

- 1.1. Climate change constitutes a serious risk for society, including (re)insurance undertakings. Global temperature is now around 1°C higher compared to the pre-industrial era and if adequate mitigation strategies are not introduced, global warming could reach 3°C or more by the end of this century (JRC, 2020). The detrimental impact of global warming on natural and human systems is already visible today and without further international climate action, global average temperature and associated physical risks will continue to increase¹, raising underwriting risk for insurers, impacting asset values and challenging their business strategies.
- 1.2. Without additional climate mitigation² (warming of 3°C or more above pre-industrial temperature by the end of the century) and adaptation³ actions, the EU could face the following impacts (JRC, 2020):
 - Total drought losses for the EU and UK would increase to nearly 45 €billion/year with 3°C warming in 2100 compared to 9 €billion/year at present.
 - Almost half a million people in the EU and UK would be exposed to river flooding each year, or nearly three times the number at present, and river flood losses would rise 6-fold in magnitude, reaching nearly 50 €billion/year with 3°C in 2100.
 - Coastal flood losses in the EU and UK would grow by two orders of magnitude and climb to 250 €billion/year in 2100, while 2.2 million people would be exposed per year to coastal inundation compared to 100,000 at present.
- 1.3. As underwriters of natural catastrophe risks, the (re)insurance sector can be particularly impacted by climate change. EIOPA published its Opinion on Sustainability within Solvency II in September 2019 (EIOPA, 2019a). The opinion sets out EIOPA's views on the integration of sustainability, in particular climate-related developments, into the Solvency II framework.
- 1.4. EIOPA noted in its Opinion that a very common argument for non-life undertakings not to include climate change-related risks in their pricing methodology is the fact that many non-life insurance business have short-term duration of contracts (typically 12-month contracts) which allow them

¹ IPCC, Global warming of 1.5°C, An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, October 2018: <https://www.ipcc.ch/sr15/>

² *climate change mitigation refers to efforts to limit the emission of greenhouse gases*

³ *climate change adaptation refers to the actions taken to lower the negative consequences of changes in the climate*

to re-price annually, which also means that they may be able to adjust the price if the risk changes.

- 1.5. However there are commercial, but also societal limits to non-life insurance repricing. In the context of climate change, the climate-related losses are expected to grow. To reflect increasing climate-related risk, the premium would therefore – leaving everything else stable – also have to increase. Over the medium-to-long term, this might lead to the risk of insurance coverage becoming unaffordable for the policyholder, as well as the industry crowding itself out of certain risks.
- 1.6. The above would contribute to a widening of the protection gap, i.e. the difference between the level of insurance (measured by insured losses) and the amount of economic losses. EIOPA’s Staff discussion paper: Protection Gap for Natural Catastrophes mentions that overall only 35% of the total losses caused by extreme weather and climate-related events across Europe are currently insured (EIOPA, 2019b). The insurance protection gap is therefore currently equal to 65%.
- 1.7. To address the insurance protection gap issue in the context of climate change, the insurance sector has the possibility to play a key role not only by transferring and pooling the risk, but also by contributing to climate change mitigation and adaptation. According to EIOPA’s Opinion on Sustainability within Solvency II (EIOPA, 2019a) “consistently with actuarial risk-based principles⁴, (re)insurance should contribute to adaptation to and mitigation of climate change.” To further illustrate and define the role of the insurance sector, EIOPA has introduced the concept of Impact Underwriting, to include “the development of new insurance products, adjustments in the design and pricing of the products and the engagement with public authorities, without disregard for actuarial risk-based principles of risk selection and pricing”.
- 1.8. The role of insurers was also emphasized in the final report on EU taxonomy developed by the Technical Expert Group (TEG) on Sustainable Finance (TEG, 2020). Non-life insurance has been recognized by the TEG to be an activity which could significantly contribute to climate change adaptation.
- 1.9. The development of the report benefited from input from stakeholders before and during the public consultation, which ran from December 2020 till end February 2021. EIOPA would like to thank the Actuarial Association of Europe (AAE)⁵, the California Department of Insurance (CDI)⁶, Insurance

⁴ In particular, a proper risk-based assessment of the premium level should be performed in accordance with the dispositions of article 48§1 of the Solvency II Directive and of article 272§6 of the Delegated regulation related to the actuarial function.

⁵ <https://actuary.eu/>

⁶ <https://www.insurance.ca.gov/>

Europe⁷, Gesamtverband der Deutschen Versicherungswirtschaft (GDV)⁸, Portuguese Association of Insurers (APS)⁹, the Swedish Insurance Association¹⁰, BEUC¹¹, Finance Watch¹² and I4CE¹³ for their valuable inputs to the initial drafting of the report, as well as all other stakeholders who commented during the public consultation. EIOPA also received comments from its Insurance and Reinsurance Stakeholder Group (IRSG). Comments received during the public consultation, as well as summary feedback to the individual responses to the consultation are available separately to the report.

- 1.10. In their feedback to the public consultation, some stakeholders noted that 'impact underwriting', subject to further clarification, can have both positive and negative impacts on availability and affordability of insurance. Price and availability of insurance is driven by two main components: risk and capacity. Impact underwriting might have effects on risk, capacity and product offerings. For example, the lack of capacity or willingness of insurers to underwrite risks related to coal-power plants or mining explorations, could drive the premium up and ultimately make such covers no longer be affordable or available¹⁴. On the other hand, it was noted that there are also many positive effects of impact underwriting from a societal perspective in respect of education, and overall higher environmental awareness of the policyholders.

Structure and purpose of the report

- 1.11. The report starts by addressing non-life underwriting and pricing principles generally. The report then highlights the challenges associated with short-term non-life contracts and annual re-pricing in the context of climate change, in order to illustrate the impact of climate change on the pricing, affordability and insurance protection gap.
- 1.12. The report identifies how insurers could address the insurance protection gap and contribute to climate change mitigation and adaptation. For this purpose, the report provides further clarification on the concept of 'impact underwriting'.

⁷ <https://www.insuranceeurope.eu/>

⁸ <https://www.gdv.de/de>

⁹ <https://www.apseguradores.pt/pt/>

¹⁰ <https://www.svenskforsakring.se/en/>

¹¹ <https://www.beuc.eu/>

¹² <https://www.finance-watch.org/>

¹³ <https://www.i4ce.org/>

¹⁴ A reduction in the availability of insurance cover for traditional solutions could lead to market distortions in some areas where (re)insurance capacity becomes limited and/ or expensive for activities deemed to promote the climate change and be detrimental to society)

1.13. The report aims at engaging with stakeholders on the key role of the (re)insurance sector to contribute, through insurance-based solutions, to climate change mitigation and adaptation.

Non-life underwriting and pricing

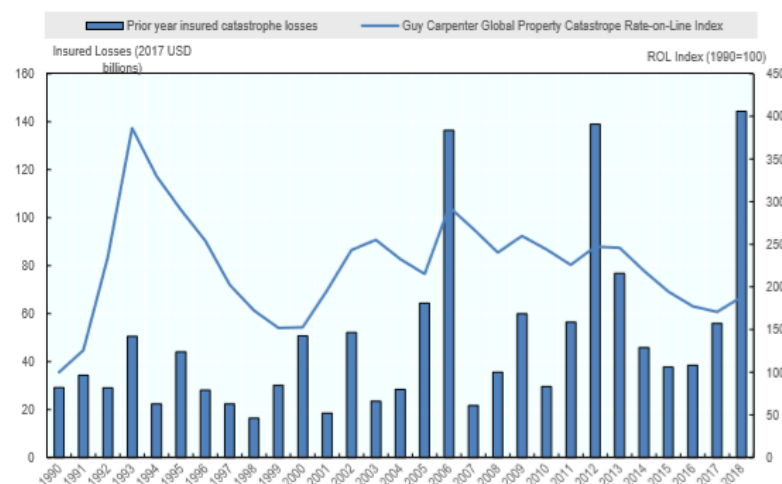
Non-life underwriting and pricing in general

- 2.1. Underwriting is the act of accepting liability up to a specified amount in an insurance policy¹⁵. To remain profitable, it implies that insurers evaluate the risk of losses attached to the insured goods (house, car, property...) or individuals (drivers, persons...). Depending of the probability of losses determined by the insurers, they will set a price, in other words, establish the insurance premium to be charged in exchange for taking on that risk.
- 2.2. Pricing is then a key part in the whole underwriting process. It needs to take into account, among others, the following aspects:
 - The overall level of premium for the various risks covered including the product design (e.g. incentives, mitigation measures, exclusions and/or deductibles)
 - The relative risk premium of different policyholders (to avoid anti-selection)
 - Risk profile analysis (e.g. risk appetite, levels of risk tolerance), including:
 - o The risk profile of policyholders
 - o The guarantees offered by the contracts
 - o The way risks are diversified in the insurer's portfolio
 - Business strategies, including capital management strategies, business planning and product development programme:
 - o The expected profit margins, taking into account costs borne by the insurers
 - o The cost of reinsurance for large claims and extreme events
 - o The cost of capital required to support the business
 - o The time value of money (investment return), in some instances where claim payments are expected to take some time, e.g. lines of business involving third party liabilities.
- 2.3. An important point to note is that reinsurers' pricing (and therefore the cost of reinsurance for a primary insurer) will be influenced by the appetite of global capital providers. After a very severe market event, while reinsurers' capital will be constrained, insurers' appetite for catastrophe protection can increase, and the cost of reinsurance will tend to increase. Conversely, more capital tends to be available after a run of good years, but catastrophe demand can decrease and reinsurance prices tend to reduce. This underwriting cycle is an important driver in overall premium levels at the customer level.

¹⁵ Definition from Collins' dictionary

2.4. Figure 1 shows the relationship between prior year insured losses and property catastrophe reinsurance pricing since 1990. Overall, property catastrophe reinsurance pricing has declined since peaks reached after Hurricane Andrew (1992), September 11th (2001), and Hurricane Katrina (2005) and declined every year between 2012 and 2017. In January 2018, following a year of significant catastrophe losses, reinsurance pricing increased by less than 10% overall although with higher price increases in regions affected by losses (e.g. Caribbean) and for reinsurance renewals on policies that experienced losses in 2017. (OECD, 2018).

Figure 1: The impact of insured catastrophe losses on reinsurance pricing (OECD, 2018).¹⁶



2.5. Beyond all the above mentioned points, a non-life insurer also considers the competitive environment in the context of pricing products. Insurers include these considerations to be able to sell their products to policyholders at a reasonable price, and with a risk that fits the risk appetite that insurance undertakings have established upfront. Commercial considerations might also be captured in the pricing, for example to launch a new product or attract new consumers.

2.6. In addition, national legislations can influence the setting of prices for insurance policies. For example, in France, a regime dedicated to the coverage of natural-catastrophes-related losses was set up in 1982, based on a public-private partnership. Applying a principle of solidarity among citizens, and due to the fact that these policies are mandatory, insurers have to charge an extra premium for the natural catastrophes coverage, set by the law as a fixed percentage of the P&C premiums of the underlying contracts.

¹⁶ *Rate on line* (ROL) is the ratio of premium paid to loss recoverable in a reinsurance contract. ROL represents how much an insurer has to pay to obtain reinsurance coverage, with a higher ROL indicating that the insurer has to pay more for coverage.

- 2.7. For non-life insurance, pricing for direct writers involves a combination of input from underwriters and actuaries. In order to determine the premium, actuaries would use technical pricing models to capture effects such as:
- Expected cost of claims, in terms of frequency and severity for "attritional" and large claims;
 - Claims inflation;
 - Analysis by specific perils within a policy (e.g. fire, theft, liability, wind, flood, hail etc...);
 - Relative riskiness of different policyholders, including allowing for geo-coding;
 - Any regulatory restrictions (e.g. inability to charge men and women different rates even if the data shows a difference in risk)
 - Likelihood of lapse/renewal at different future points of re-pricing;
 - Price elasticity and customer behaviour;
 - Variations in profit margins;
 - Cost of reinsurance and capital;
 - Expenses and investment returns;
 - Discounting of future cash flows.
- 2.8. The actuarial analysis is one input to pricing decisions, and is overlaid with competitor analysis and underwriters' expert judgement to arrive at the customer premium.
- 2.9. For extreme weather insurance to be provided, the risk must meet the following conditions (Charpentier, 2008):
- 2.10. Actuarial insurability:
- The extreme weather event occurs randomly (i.e. a certain probability within a year)
 - The maximum possible loss should be reasonable compared to the insurer's solvency requirements
 - The loss should be identifiable and quantifiable
 - The losses should be relatively uncorrelated, so that risks can be pooled following the Law of Large Numbers.
- 2.11. Economic insurability:
- There should be limited consequences from information asymmetries (i.e. moral hazard and adverse selection)
 - The willingness of consumers to pay for an insurance policy should exceed the premium level for which insurers are willing to accept the risk transfer.
- 2.12. When these conditions are met, a viable insurance market for an extreme weather event can be provided. The actuarial insurability criteria result in the insurer translating the risk in monetary terms, while the economic insurability criteria allow the market to find a fair price that result in a market equilibrium of supply and demand.

Non-life underwriting and pricing in the context of climate change

- 2.13. Climate change poses a number of challenges to the insurability of climate-related risks. Indeed, if the intensity of events increases significantly, it could challenge the fact that the maximum possible loss should be reasonable compared to the insurer's solvency requirements. Climate change also means that the assumption that past losses are a reliable way to estimate future losses may no longer hold true. It will therefore be more difficult to quantify potential losses. In addition, climate change could also impact the randomness and correlation of events. The BIS (2020) mentions that "green swan" risks¹⁷ could be behind the next systemic financial crisis. The complex chain reactions and cascade effects associated with both physical and transition risks could generate fundamentally unpredictable environmental, geopolitical, social and economic dynamics.
- 2.14. In addition, in light of climate change, the premiums might also increase to reflect the increasing risks. The willingness of consumers to pay for an insurance might be lower than the premium for which insurers are willing to accept the risk transfer anymore, which makes an insurance market for climate-related events non-viable.
- 2.15. Based on the main underwriting and pricing elements described in the previous section, EIOPA tried to identify the different ways climate change would materialise in the underwriting and pricing elements of non-life insurers.
- 2.16. The following list of elements (factors or parameters) is the result of a first assessment and serves as an indication:

Table 1: Result of a first assessment - Elements in the non-life pricing process which will be influenced by climate change (physical, transition and liability risks).

Element	Influenced by climate change
Frequency of events	In general, extreme weather-related events are expected to become more frequent as climate change continues. Note that the extreme weather can range from drought (causing wildfires and crop failure) to a higher probability of landfall hurricanes (causing widespread property damage and flooding). This means that analysing past frequency of these events may not help when estimating the future frequency of events. From a pricing perspective, any manual adjustments to observed frequency should be done with care and

¹⁷ Green swans, or "climate black swans", present many features of typical black swans. Climate-related risks typically fit fat-tailed distributions: both physical and transition risks are characterised by deep uncertainty and nonlinearity, their chances of occurrence are not reflected in past data, and the possibility of extreme values cannot be ruled out.

	<p>validated by the technical pricing and underwriting teams.</p> <p>It is important to ensure that the frequency assumptions are appropriate for the risk period, to sense-check outputs and consider a range of scenarios to understand how sensitive the results are to changes in frequency of events.</p>
Severity of events	<p>Similarly to the fact that the frequency of certain weather-related events will be impacted by climate change, the severity of these events will also change due to climate change.</p> <p>It is then also important to ensure that the severity of events will be properly assessed, based on climate-related risks scenarios and future trends, to define prices.</p>
Exposure	<p>(Re)insurers will need to manage exposures very closely to avoid accumulations of risk in areas that might experience a higher frequency and severity of extreme weather events.</p>
Information needed for risk assessment (notably as regards adaptation to climate change by (prospective) policyholders)	<p>Current or prospective policyholders may to varying degrees undertake investments in climate resilience or take other actions to adapt to climate change. Such impact of climate change on the behaviour of individual policyholders can affect the underlying risks and may necessitate updates in insurers' risk assessment.</p>
Location of events	<p>The location is deemed extremely important when pricing climate-exposed risks. If the frequency and severity of extreme weather events in developed countries increases, then it could lead (re)insurers to reconsider the number and location of risks they are willing to cover; and/or to define tighter terms and conditions, higher deductibles, and lower limits. This could ultimately increase the amount of risks deemed uninsurable.</p>
Insured loss	<p>As climate change takes hold, insured losses are expected to increase. This will directly affect the pricing of risks. Again, there will be uncertainty as to how relevant past data will be for future events, as well as second-order effects like demand surge.</p>
Terms and conditions	<p>Given risk assessments going forward, insurance undertakings may consider changing their terms and conditions to exclude for example some aspects from insurance coverage due to uncertainties beyond an insurable level. (Re)insurers might also include higher deductibles and lower limits to mitigate the insured risk.</p>
Reinsurance availability	<p>Primary insurance companies use reinsurance coverage to protect against extreme events. If such events become more likely and more severe</p>

	<p>in the future, it can be expected that the cost for reinsurance would increase, or that reinsurance conditions for certain perils or regions would begin to change. In response, primary insurance needs to consider such trends.</p>
Cost	<p>Climate change can increase the number of claims and in turn increase the costs for claims resolution. It may require insurers to better assess and manage their risks, notably with a more granular risk segmentation. This could potentially increase the costs by individualizing the client relationship (i.e. design personalised and tailored insurance products and service offers based on consumers' behaviour in light of climate-related risks).</p>
Competitive considerations	<p>Insurance undertakings need to assess the competitive environment they operate in in order to on the one hand react to policyholder preferences (e.g. looking for more sustainable investment options within saving-oriented life insurance products), or on the other hand assess the ability to adjust premiums going forward.</p> <p>Competition in the Single market will necessarily be impacted by climate change depending on the insurers' portfolios exposures to climate-related risks. Competition could then increase in the safer areas where risks do not need to be repriced significantly and, at the opposite, competition could be distorted in the riskiest areas (where insurers that have a higher exposure to climate-related risks in their portfolio will have to increase their prices compared to other less exposed insurers).</p> <p>To lower their risk exposures, insurers can increase the segmentation of risks. This could have consequences on competition: 1/ it could generate windfall effects at short term (i.e. insurers could develop such practices to reinforce their position on the market by increasing prices to exclude "higher risks" and to net their risk exposures) and 2/ it could reduce globally the accuracy of competition by impacting the transparency on prices and terms and conditions, while individualizing the client relationship.</p>
Investments and Economic Environment	<p>Insurance undertakings have significant investments that serve the interests of policyholders. A changing investment landscape poses challenges such as avoiding exposures to potentially stranded assets. Going forward, not all possible impacts can be foreseen; therefore,</p>

	continued efforts are needed to safeguard the policyholder's interests.
Insurability	Climate change might make certain perils uninsurable (if they become too frequent for example).
Cost of Capital	In order to adequately reflect the risk, capital cost might need to reflect climate change. This could potentially lead to higher cost of capital.

Annual re-pricing of short-term contracts in light of climate change

- 2.17. The above table shows that climate change will impact multiple aspects of the underwriting and pricing process of non-life insurance companies. However, a common practice from undertakings is to not include climate change-related risks in their pricing methodology, as many non-life insurance businesses have short-term duration of contracts (typically 12-month contracts) which allow them to re-price annually. In repricing annually, climate change would be implicitly reflected by including recent events in their analysis based on historical data. This means that longer-term trends such as climate change would be reflected gradually over time by adjusting policy terms and conditions annually; and it assumes that the constant monitoring of loss impacts is sufficient to tackle the developing impact of climate change.
- 2.18. The rationale for the relative short-time period of a non-life product can be interpreted in light of EEC directive 93/13EEG of 5 April 1993 regarding unfair conditions in consumer contracts. The short duration protects consumers or businesses from being bound for a long period to an insurer when they would not be satisfied with the insurance companies handling or the insurance price. In the EU, some Member States have statutory provisions that limit the duration of the contract to one year (such as Sweden for example). Many insurance policies in Member States with one year contracts nonetheless contain provisions for tacit renewal or prolongation (COM, 2014). This also means that the (re)insurance company is able to change conditions and rise premium on an annual basis.
- 2.19. The AAE mentions that from a non-life perspective, it is a valid argument from each individual insurer's point of view to say that prices cover only the next year as insurance policies for property insurance are normally issued as annual contracts (Kleindorfer, 2012) and longer-term trends such as climate change will be reflected gradually over time.
- 2.20. Catastrophe models used to help actuaries defining technical price for Nat Cat insurance products are for example updated regularly with new sets of parameters that are calibrated including the latest events.

- 2.21. In practice however, the AAE mentions that reinsurers' pricing will be also influenced by the appetite of global capital providers and the reinsurance pricing cycles associated to the occurrence of extreme events.
- 2.22. In addition, for commercial reasons, customer relationships considerations mean that a (re)insurer might also not be able to re-price the contract annually even if from a pure contractual point of view it would be possible.

Lessons from past events

- 2.23. Past events have already shown that it will not always be possible to adjust gradually premiums over time when the risk increases. Indeed, when a number of major events struck, the (re)insurance sector reacted by increasing significantly the premiums, adding policy exclusions or refusing to renew cover, which ultimately left the policyholder with no coverage or with difficulties to pay for such coverages.
- 2.24. According to Schwarze and Wagner (2007), the response of German insurers to the "Flood of the Century" in 2002 was to increase premiums and withdraw coverages for highly exposed areas. Economic losses from the German flood disaster of 2002 were estimated at €11.6 billion. Mindful of the rising exposure to risk, German insurers reduced coverage in high-risk areas and increased premiums and deductibles. Previously, the calculation of premiums was based on maximum flood-related losses of €2.5 billion and an observation period of 100 years. After the event the basis of calculation is a total of €11 to €15 billion and an observation period of 200 to 300 years. Premiums increased in high risk regions of Saxony up to 60 per cent. At the same time, overall insurance penetration increased according to GDV statistics¹⁸ since 2002 also as a consequence of increased prevention measures as well as availability of flood data in relation to the EU Flood Directive from 2007/60/EC.
- 2.25. After the 2004 and 2005 hurricane seasons many insurers did not renew coverage for a significant number of homeowners in the Gulf Coast (Klein 2007). While most of those residents were able to find coverage with other insurers, they typically had to pay a higher price than prior to these disasters and they were required to have a higher deductible (Vitelo, 2007).
- 2.26. In Australia, in 2012 a private insurer temporarily withdrew insurance cover from two towns which were flooded three times in 2 years, causing significant losses. The insurer held a high market share in this region and at that time there were not many competitors offering flood insurance on the market (McAneney et al., 2016).

¹⁸ <https://www.gdv.de/resource/blob/63646/8773773d8c7ee6f705a146eaa9bba54c/publikation---naturgefahrenreport-2012-data.pdf>, page 36

- 2.27. In 2017, the California Department of Insurance (CDI) has seen cases where homeowners were paying an annual premium of \$800-\$1,000 but, upon renewal, saw increases to as high as \$2,500-\$5,000 and this was before the dramatic 2018 and 2020 wildfire events (CDI, 2017). In 2018, insurance companies decided to drop fire coverage for over 88,000 residents in California after a disastrous wildfire season, a 6 percent increase in non-renewals compared to 2017. According to the CDI, between 2015 and 2018, nearly 350,000 rural homeowners lost wildfire insurance, being forced to find replacement coverage, which ended up at much higher premiums. Withdrawal of insurance from already existing built-up areas might become more likely in the future (Lamond and Penning-Rowsell, 2014).
- 2.28. EIOPA also asked European insurance associations (APS, GDV and Swedish insurance association) to identify lessons learned from selected past natural catastrophes.
- 2.29. For the Nat Cat events chosen by the insurance associations (2017 Forest Fire in Portugal, 2014 flood event in Sweden and 2013 Flood event in Germany) evidence was that the insurance sector did not reprice nor stopped offering coverage in the region impacted by the event (see Annex).
- 2.30. In all three examples, it was noted that climate change is expected to have a significant impact on similar type of events in the future and will very likely increase the potential damages in the future. The different events have also highlighted the need to take prevention measures to reduce the potential impacts of these events.
- 2.31. Where government financial support is in place, such as for example in Portugal, it was noted that this may hinder the take-up of insurance, based on the public's perception that the government will step in to cover for losses eventually.

Impact of climate change on future premiums, affordability and insurance penetration

- 2.32. In light of climate change, the annual repricing may lead to insurance becoming unaffordable over a longer term period, and disincentivising consumers from taking up insurance. When broader shares of the population, especially in regions more affected by climate change, are not insured anymore the protection gap and the financial exclusion (more importantly for lower incomes and vulnerable customer) increase.
- 2.33. The study of Tesselaar et al. (2020) on the impacts of Climate Change on EU flood insurance markets shows that in the context of climate change, annual re-pricing will not be sustainable as the increase of premiums for flood insurance increases the amount of the population which cannot afford flood insurance in the future.
- 2.34. By using a dynamic integrated flood insurance model, they estimate insurance premiums for different flood insurance systems under various

scenarios of climate change. They found that on average flood premiums are projected to rise with a factor of ~ 3.5 up to 2080 for RCP4.5¹⁹. Under the RCP8.5²⁰ scenario, this growth is estimated to be equal to ~ 4.5 . The premiums vary significantly between different Member States.

- 2.35. As a second step of the analysis, the estimated premiums for the different climate change scenarios were fed into a consumer behaviour module where households' decisions for purchasing insurance and implementing Disaster Risk Reduction (DRR) measures are simulated. As a result of climate- and socio-economic change, the percentage of the population that cannot afford flood insurance is also expected to increase. Under constant soft reinsurance market conditions, the percentage of households in high-risk areas for whom flood insurance is unaffordable rises from 23% in 2020 to 36% in 2080 for RCP4.5, while it rises to 41% under RCP8.5.
- 2.36. Finally, based on the estimations of premium increase and unaffordability, they modelled the future flood insurance penetration rate for the EU countries. The study identifies that with voluntary insurance systems, the uptake declines to such an extent that the majority of the population at risk of flooding is not covered by insurance, and is therefore not protected against flood risk.
- 2.37. Another study from the association of British insurers (ABI, 2009a) investigated the potential impact from a changing climate on pricing and required minimum capital under Solvency II. Their results showed that the inland flood component of insurance premiums could increase by around 21% across Great Britain assuming a global temperature rise of 4°C. The insured inland flood loss in Great Britain occurring on average every 100 years could rise by 30%.
- 2.38. In summary, climate change impacts the insurance underwriting and pricing activities in multiple ways. Annual repricing of the risk is indeed possible (although not always used due to other considerations). However, steady annual premium increases (or similar actions such as higher deductibles or wider exclusions) could have unintended consequences such as unaffordability or unavailability of insurance, leaving an increasing share of the risk uninsured. Without a broad set of measures to address this issue, insurance coverage may decrease and the protection gap may correspondingly increase over time.

¹⁹ Greenhouse gas emission scenario in line with the 2 C target of the Paris climate accord.

²⁰ Extreme scenario of greenhouse emission aligned with a future where a high dependency on fossil fuel remains.

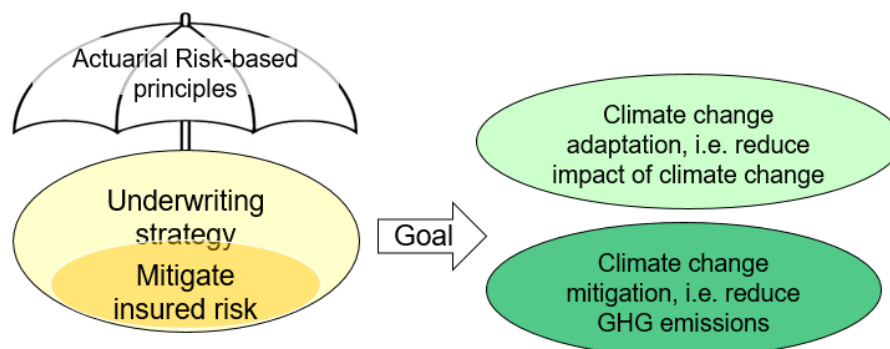
Options to ensure availability and affordability of insurance in light of climate change

Impact underwriting

- 2.39. The fact that non-life insurance contracts are short-term contracts and can be annually re-priced has been presented as one of the main reasons to not capture climate change in the actuarial pricing beyond the one-year time-horizon. Within the regular update of assumptions, recent trends within historic data are being integrated into the respective forward-looking assumptions. However, this argument may not be sustainable in the mid- to long-term as it will lead to unaffordable coverages or withdrawal of coverages, as already shown by past events. Consumers may also not buy/cancel insurance as they cannot pay for it anymore. While premiums need to remain risk-based, and reflect the risks insurers and consumers or business are exposed to, (re)insurers, as risk managers, can also contribute to reducing the risks caused by climate change. Some insurers are already doing so in multiple ways, e.g. by providing services to policyholders. They have the possibility to make policyholders change their behaviour, consequently contributing to climate change adaptation or climate change mitigation.
- 2.40. In its concept of impact underwriting, EIOPA aims to capture these challenges and opportunities, and based on this, the paper puts forward options for implementing climate change adaptation and/or mitigation through pricing and underwriting.

Definition of impact underwriting

Consistently with actuarial risk-based principles, (re)insurers, as risk managers and underwriters, can contribute to climate adaptation and mitigation by applying their data, expertise and risk assessment capacity to incentivise policyholders to mitigate insured risks via risk-based pricing and contractual terms, and consider in their underwriting strategy measures that contribute to climate change adaptation and/or mitigation.



- 2.41. Other ongoing initiatives are promoting climate-resilient underwriting practices in the insurance sector, among which the EU Taxonomy for Sustainable Activities (which has included insurance as an activity eligible to making a substantial contribution to climate change adaptation), and a group of leading insurance companies who have started making public commitments towards net-zero underwriting targets.

Ongoing initiatives to promote climate-resilient insurance

EU Taxonomy for Sustainable Activities

The EU Taxonomy Delegated Regulation²¹ provides a catalog of sustainable economic activities, with six main sustainability objectives in scope. The implementation of these objectives through 'technical screening criteria' for the various economic activities, starting with climate change mitigation and climate change adaptation is being further laid out in the Climate Delegated Act.²² The other four objectives are still under development at the time of writing this report.

The alignment of individual economic activities with the Taxonomy is subject to screening criteria :

- i. Substantially contribute to at least one objective;
- ii. Do not significantly harm the other objectives; and
- iii. Comply with minimum safeguards.

Reflecting the dual economic role of the insurance sector, insurers are both:

- i. Users of the Taxonomy as institutional investors; and
- ii. Eligible as underwriters for the climate change adaptation objective: non-life & reinsurance products covering climate-related perils are in scope, subject to strict screening criteria linked to the insurance product itself (prevention measures, data sharing etc.) and to the exclusion of all insurance activities related to fossil fuels.

The EU Taxonomy also sets out mandatory disclosure requirements. In particular, insurers reporting key performance indicators on

²¹ Regulation (EU) 202/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Taxonomy Regulation), https://ec.europa.eu/info/law/sustainable-finance-taxonomy-regulation-eu-2020-852_en

²² Commission Delegated Regulation (EU) .../... supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives ('Climate Delegated Act'), April 2021, pending adoption by the European Parliament and the Council: http://ec.europa.eu/finance/docs/level-2-measures/taxonomy-regulation-delegated-act-2021-2800_en.pdf

environmentally sustainable activities, in non-financial statements under the Non-Financial Reporting Directive, will have to publish the premium ratio of their underwriting activities aligned with the Taxonomy's criteria.

Net-zero underwriting targets

In parallel, leading insurance companies have started making public commitments towards net-zero underwriting objectives. Calls have been made within the insurance industry supporting the creation of a UN-convened 'Net-Zero Underwriting Alliance'²³ that would see member companies from across the insurance sector align their business activities with the 1.5C warming pathway required under the Paris Agreement, similar to the Net Zero Asset Owners Alliance and the Net Zero Asset Managers Initiative.

The primary focus of the net-zero underwriting concept is on the emissions of the insured objects and the wider climate change mitigation objective, thus providing a different perspective from the EU Taxonomy. It might involve not only the selection of the insured risks based on environmental criteria, but also the engagement with risk ceders to incentivise them to transition towards meeting these environmental criteria.

Methodologies for measuring the carbon footprint of an underwriting portfolio are still under development at the time of writing, see for example CRO Forum, 'Carbon footprinting methodology for underwriting portfolios' (2020).

2.42. In the following sections we present three options for implementing 'impact underwriting':

- Contribute to climate change adaptation or mitigation via risk-based pricing and contractual terms
- Consider long-term insurance, and
- Products and services as part of the underwriting strategy which aim at contributing to climate change adaptation and mitigation.

2.43. When considering the below options, a number of aspects are relevant to consider:

- The micro versus macro impact: these options refer to insurance practices which would be applied at individual policyholder level. However, in order to have an impact at macro level, these measures would need to be applied for a large number of customers and for institutional clients²⁴;

²³ <https://www.unepfi.org/climate-change/un-convened-net-zero-insurance-alliance/>

²⁴ EIOPA (2019a), §5.50

- Greenwashing: the lack of common standards (labels, taxonomy) to define and measure the contribution of products and services to climate change mitigation and/or adaptation can increase the risk of greenwashing, where undertakings' climate change strategies would be merely marketing tools;
- Financial exclusion: some options might also imply higher costs for the policyholder. This might be a challenge for lower incomes and vulnerable customers, and may require solidary solutions involving public actors.
- Additional costs to policyholders: trying to mitigate and/or adapt to climate change could potentially increase the costs by individualizing the client relationship (i.e. design personalised and tailored insurance products and services offers based on consumers' behaviour linked to climate-related risks).
- Policyholder information on prices and on terms and conditions: individualized customer relationship and differentiated pricing and contractual terms could impact the quality of information of policyholders.
- Big data: in order to better adapt the insurance products or services to the customer's need or behaviour, significant amount of data are needed (e.g. geolocation data, miles driven, driving behaviour (harsh braking, speeding, time of day, road type...) (EIOPA, 2019c). The development of impact underwriting practices may therefore also make use of on big data analytics, artificial intelligence and algorithmic decision-making. When using these technologies to design personalised and tailored insurance products and services, a number of risks might arise for the policyholder. Concerns about the use of personal data to define the coverage and the corresponding price for policyholders may therefore increase. As these technologies would enable further risk segmentation and individualisation of the product, this could also lead to higher financial exclusion and to demutualization of risks (i.e. end of risk pooling and solidarity).
- Future of insurance sector: The insurance sector is evolving. The insurance model is shifting from reimbursing claims to preventing claims. The future of the insurance sector will also involve more customer services.

2.44. Many stakeholders also highlighted that equalization provisions can provide a way to factor in the longer term increases in claims and costs. Such statutory provisions are not recognized under Solvency II or IFRS as provisions, but as own funds. However, in several member states taxes are based on local GAAP and funding equalization provisions can provide a deductible means to create longer term financial buffers. These equalization buffers can then be used to pay out claims during years of higher loss ratios due to climate change, thus dampening price fluctuation and helping maintain the availability of protection.

Contribute to climate change adaptation or mitigation via risk-based pricing and contractual terms

- 2.45. One mechanism to stimulate policyholders to adopt risk-reducing behaviour is the use of risk-based premiums and deductibles, where the premium should reflect the actual risk a policyholder is exposed to. If the risk increases, the price or deductible would be higher. The price of insurance, the contractual terms and the conditions under which insurance is offered, are generally strong signals about the risk, even if commercial considerations also determine the price of insurance. By taking measures that influence the price, or the contract, insurers send a message on how they are managing the risks.
- 2.46. In a perfect market, with well-informed and rational-acting market participants, insurers would earn enough premiums to cover all losses and policyholders would implement risk reduction measures when it is economically reasonable for them. A resulting reduction in risk would then mean that the insurance company requires less money to cover the losses, and thus premiums and deductibles could decrease (Seifert-Dähnn, 2018).
- 2.47. In reality, however:
- Premium calculations often do not only follow actuarial principles, but are restricted by legislation. For example, in France, premiums for Nat Cat coverage are a flat 12% surcharge on property insurance.
 - Bundling of risks. For example, a specific Nat Cat risk is often bundled with other risks so the premium does not reflect a single risk (reflecting individual risks and risk reduction measures is therefore more difficult). Bundling multiple natural hazards (France, Portugal, Switzerland, and Iceland), fire (Belgium, Denmark), or building/household insurance (USA, Spain) is very common (Lamond and Penning-Rowell, 2014).
 - Premiums are cross-subsidized, either within a peril, between low and high risks, or between perils. For example, in the USA, policyholders in low risk areas are charged a higher premium than the one which would be adequate for their risk, and thus subsidize high-risk areas where a risk-reflective premium is considered to be too high to be affordable by policyholders (Kousky, 2017).
 - Market competition in private markets can be so high that insurers may keep the premiums artificially low to attract more customers; this is for example the case in the UK (Priest et al., 2016).
 - Policyholders or potential policyholders do not always behave rationally; people tend to underestimate risk probability and their need for insurance (Botzen et al., 2013). Their decision to purchase insurance relies on their risk perception, previous experience, previous provision

- of governmental loss compensation, and other factors (Seifert et al., 2013).
- Tailored prevention and risk engineering services are more commonly provided by insurers to their corporate clients than to retail customers. For the latter, the growing business model of digital underwriting might make it harder for the insurer to provide individual risk advice and discuss relevant prevention measures. In addition, the cost of providing additional risk services may also need to be reflected in the premium.
- 2.48. In insurance pricing today, generalisations are typically made for local areas and types of buildings to approximate the level of risk. This is sufficient where risks are well diversified. However, to provide appropriate economic incentives, premiums would need to more accurately reflect risk and in particular, the reduction in risk associated with investments in property-level resistance and resilience. For this, the underwriting process would require a higher degree of information and the administrative costs of the policy would rise accordingly. A particular concern is the need for on-site verification of the level of protection. Regular validation would be required, perhaps by a third party, to confirm that protection measures were present and adequately maintained. This would require additional costs.
- 2.49. For these reasons, it is difficult and not common practice to reflect prevention measures, which could reduce the risk, in risk-based premiums today (Seifert-Dähnn, 2018).
- 2.50. Nevertheless, examples exist for pricing reflecting risk reduction measures which would contribute to climate change adaptation:
- 2.51. In Germany, individual agreements to insure single high-risk properties seem to become more common, and reduced deductibles and premiums are used to reward property-level protection measures (DKKV, 2015).
- 2.52. In 2012, a coverholder of Lloyd's introduced a catastrophe insurance policy in the Netherlands, which allows homeowners to purchase insurance coverage for flood damage bundled with earthquake and terrorism risks (Surminski et al., 2015). From a disaster risk reduction perspective, this insurance aims to raise risk awareness and charges risk-based insurance premiums on which policyholders receive premium discounts if they take measure to "floodproof" their home. Flood risk information is provided on the insurer's website, on which individuals can enter their zip code level to access location specific information about flood probabilities, quality of flood defences, potential water levels, and the risk based insurance premium. Four different measures are eligible for a premium discount of 5% each: namely, (i) installing electrical equipment and (ii) the central heating installation above the ground floor level, (iii) having flood shields available, and (iv) having a water-resistant floor on the ground floor level, such as tiles. However, this insurance product is unlikely to result in broad insurance coverage of flood risks in the Netherlands, because it is only available for

homeowners and not for tenants, its availability per dike ring area is limited, coverage is limited to €75,000 per policy, while the premium is relatively high compared with estimates of homeowner's willingness to-pay for flood insurance (Botzen and van den Bergh 2012a, b).

- 2.53. The National Flood Insurance Program (NFIP) in the USA calculates full-risk premiums (i.e., unsubsidized premiums) by considering risk zones as well as the type of property, and certain property characteristics such as the number of floors, existence of a basement or elevation, and several premium adjustment factors in addition (Kousky, 2017).
- 2.54. In South Carolina (USA), legislation relating to 2016-2017 General Assembly Act 28, requires insurers admitted by the state to offer premium discounts, on portions of premium attributable to wind losses, for mitigation measures that strengthen coastal homes and business against hurricane damage (South Carolina Department of Insurance, 2016). The insurance company Travelers²⁵ introduced in 2012 a wind credit for fortified homes²⁶ in Texas that meet established standards designed to resist the impacts of tropical storm and hurricane winds²⁷. Travelers offers similar credits in Alabama and Mississippi.
- 2.55. In addition, other examples exist where insurers also offer differentiated premiums for products which could contribute to climate change mitigation:
- 2.56. For example, some insurance undertakings implemented a premium discount for "green" or low-emission vehicles (electric, hybrid, gas-powers vehicles which emit less greenhouse gases than standard vehicles) and for cars with a combustion engine. The lower motor insurance premium may incentivize the policyholders to choose low-emission vehicles and consequently contribute to climate change mitigation. However, the fact of using low-emission vehicles or standard type of vehicles does not directly affect the insured risk. The insured risk level remains a priori the same irrespective of whether a low-emission or standard vehicle is insured. However, other secondary considerations with an indirect impact on the risk insured, such as behavioural data, could also be accounted for (for example if data showed that drivers of eco-vehicles are driving more prudently than the general population).
- 2.57. Some insurance undertakings also decided to define a premium discount on insurance products covering property losses from nat cat events for green-

²⁵ <https://www.travelers.com/>

²⁶ In the US, the Insurance Institute for Business & Home Safety (IBHS) is a non-profit research and communication organization supported by property insurance and reinsurance industries. IBHS developed the FORTIFIED Home program to promote construction and retrofitting of homes for resilience to natural disasters. According to IBHS, FORTIFIED is a nationally recognized building method that goes beyond building codes to strengthen residential and commercial buildings against specific natural hazards such as high winds and hurricanes.

²⁷ <https://www.travelers.com/tools-resources/home/renovation/renovating-your-home-to-fortified-standards>

certified building owners. Buildings with green certificates, e.g. energy-efficient, solar or earth-sheltered, can contribute to risk mitigation by reducing greenhouse gases emission. Premium reduction can incentivize the policyholders to build or develop buildings in a sustainable way. However, the fact that the building emit less greenhouse gases does not directly affect the insured risk level. Assuming that the certification process does not relate to making the building more resilient to natural catastrophes, the risk of damage from fire, flood or hurricane remains the same. Premium discounts in the circumstances described above would not be based on risk reduction. Other parameters could be taken into account where insurers are able to assess that the risk profile of the owners of a green house is lower based on behavioural data. For example, some insurers noted that commercial property owners and homeowners who carry out green practices are more risk-management-minded and tend to be in lower risk categories. Additionally, green appliances and heating and cooling systems are safer, as they run cooler on less electricity, minimizing the risk for fires. Insurers might also want to account for the fact that emitting less greenhouse gases contributes to mitigating climate change, and therefore contributes to diminishing the probability of having nat cat events. It might however be not straightforward to clearly quantify this effect to estimate a premium discount.

2.58. Risk reduction measures could also be reflected in insurance contracts more broadly. However, the following considerations note that the potential of using deductibles and indemnifications may be more limited:

- Bräuninger et al. (2011) argue that risk-reflecting deductibles might be far more effective in promoting risk reduction behaviour than premiums, when they are in a similar order of magnitude as the costs for property-level protection measures, and thus the profitability of an investment becomes more obvious to the policyholder. A recent study of Den et al. (2017) found that the use of deductibles is widespread in Europe, but that these deductibles are relatively small, i.e., not in the range of what most property-level protection measures would cost, and thus the incentive given by the deductible must be regarded as limited. An argument against the use of deductibles as incentives for taking risk prevention measures is that these are uncertain future costs for policyholders, and that policyholders will not notice the cost-effectiveness of property-level protection measures in comparison to deductibles before a flood hits them (Priest et al., 2016). Premium reductions are more immediate and tangible benefits; i.e., the policyholder will notice them each time they pay their premiums.
- Indemnification limits, i.e., a capping of the amount of compensation policyholders can receive, are, beside deductibles, another possibility of sharing the financial burden between insurers and policyholders. Indemnity limits as a percentage of the property value insured are

practiced in Austria and Italy (Den et al., 2017), as well as in the USA (Lamond and Penning-Rowsell, 2014). Loss limits per event or per year are practiced, e.g., in Belgium, Iceland, and the Netherlands (Priest et al., 2016). Indemnification limits can be considered to be even less tangible than deductibles, as they only affect policyholders when it comes to high flood losses. This is mainly the case when a low-probability event, i.e., an extremely strong event, hits, when many property-level protection measures such as mobile walls would fail to protect the property anyhow. Hence, it follows that the use of indemnification limits as an incentive to promote risk adaptation is likely not feasible.

- 2.59. It could be useful to distinguish between an insurance company's technical pricing and its underwriting policy. The actuarial assessment of the risk insured is and should remain the bedrock of technical pricing. However, allowance is routinely being made by insurers for wider topics (e.g. reputation, competition, business model) in their underwriting policy and in the commercial premium ultimately paid by policyholders. This can potentially include climate mitigation objectives and longer term sustainability considerations to help promote the insurer's role in the climate transition (as is seen for example in the coal underwriting policy already implemented by several companies). Such wider underwriting considerations from individual private insurers could potentially be supported by coordinated industry initiatives, government incentives (e.g. fiscal policy, land-use planning), the establishment of Public-Private Partnerships and/or regulatory requirements that would apply to all market participants.

Consider long-term insurance

- 2.60. As opposed to life insurance contracts, non-life policies are typically short-term (one year), allowing insurers to reassess the risk on an annual basis and policyholders to switch to a new insurance provider without financial surrender penalties. However, multi-year contracts, otherwise known as "long-term insurance", which provide a guaranteed price (or guaranteed ceiling and floor price) over a term from 3 to as much as 25 years, could have significant benefits for adaptation by providing greater incentives for the insured to invest in cost-effective property-level resistance and resilience measures (Maynar and Ranger, 2012).
- 2.61. In practice, insurers for example offer multi-year contracts for life insurance where the losses are normally independent of each other. Term-life policies are typically offered with premiums "locked in" for five to ten years; buyers can choose whether they want to pay extra for such guarantees over annual contracts knowing that they may drop coverage at any time. Policyholders are then certain what their life insurance premiums will be over the next

five or ten years, regardless of what happens to their health or the overall mortality rate of their insurer's portfolio (Kunreuther and Michel-Kerjan, 2015).

- 2.62. Life insurers also customarily offer long-term guarantees in their savings products. The financial risk is not diversified away between policyholders, but there is an expectation that there will be fluctuations of financial markets over time, with favourable years compensating adverse ones in the long run. In a number of jurisdictions, this long-term view of the risk appetite is encouraged by the governments granting tax rebates to policyholders who leave their money in the insurance product during a minimum number of years. Similar incentives could be explored for non-life products in the context of climate change.
- 2.63. An important difference between property and life coverage is that for non-life catastrophe risk insurers have to reserve capital to protect themselves against catastrophic losses to property due to extreme events caused by natural disasters such as hurricanes and earthquakes. There is an opportunity cost to keep this capital in relatively liquid form rather than investing the money in securities, as for example for life insurance, which earns a higher expected return (Kleindorfer et al. 2012).
- 2.64. A multi-year contract in non-life insurance could have the following advantages (Maynar and Ranger, 2012):
 - strengthen the economic incentive by making investments in risk reduction over a longer time frame and showing the medium-to-long term benefits of this investment more visible upfront;
 - provide financial certainty for the policyholder and a guarantee of insurance coverage over the longer (i.e. beyond 1-year) policy term (property-owners could be assured that the insurer would continue to provide the premium discount, enabling better informed financial planning by the policyholder);
 - decrease the transaction or search costs to policyholders in a case where annual policies are not renewed by their insurer (though search costs may increase per policy as multi-year contracts mean more complex decisions);
 - reduce administrative costs for the insurer and increase certainty by reducing the turnover of customers;
 - encourage a higher degree of insurance coverage across society with benefits to individuals and society as a whole. For example, in some markets, policyholders tend to cancel or not renew contracts if no losses have occurred and this can leave them, and society, more exposed when an event occurs;
 - increase the incentive for the insurer itself to invest in improving the resistance and resilience of the insured properties and to transition from claims reimbursement to claims prevention.

2.65. However a number of disadvantages comes with multi-annual contracts (Maynar and Ranger, 2012):

- Higher premiums and lower flexibility for policyholders: The higher price of a multi-year contract means that for the policyholder there is an advantage of a shorter policy term. In the survey carried out by the Association of British Insurers (ABI) in 2009, many respondents were concerned about the possible disadvantages of multi-year contracts (Goss and O'Neill, 2010). The advantage of an annual contract for the policyholder is that it provides flexibility and choice; the option to renew or renegotiate a contract, or switch to an alternative insurer, to ensure that they get the best price and conditions for insurance. This must be weighed against the disadvantage that prices may increase over time, as well as the potential higher search costs if a policy is cancelled by the insurer.
- Lower flexibility for the insurer and less efficient use of capital: For the insurer, a multi-year contract has the advantage of limiting turnover in policyholders, but also limits the ability of the insurer to renegotiate the contract or cancel in response to changing conditions or new information; this could mean greater liability, but also an increase moral hazard. In addition, the flexibility to raise premiums if necessary after a disaster is an important 'pressure valve' for the (re)insurance markets. For the insurer it is an important way to rebuild their balance sheet. Without this pressure valve, more capital would need to be held in the first instance and premiums would need to be set higher. This not only implies a higher premium but also a less efficient use of capital and associated opportunity costs to the insurer. The inability to rebuild the balance sheet in the event of a significant loss may be seen by private non-life insurers as an impediment to offering multi-year contracts (although reinsurance may be used as a tool to counteract such adverse effects on capital). The European Commission has also stated that long-term contracts can have exclusionary effect when their cumulative effect causes market foreclosure giving rise to concerns under competition law (EC, 2007)²⁸.
- Long-term guarantees and the risk of insolvency: the likelihood and impact associated with mispricing a policy are larger than for an annual contract, where premiums can be adjusted each year in response to new information. In extreme cases, large-scale mispricing could lead to insolvency. As in the life insurance case, a multi-year property insurance is effectively providing a guarantee against interest rate changes, capital market fluctuations, changes in expenses (e.g. due to regulation) and other regulatory changes. A multi-year policy with guaranteed premium

²⁸ <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52007DC0556>

has no opportunity to adapt to the changing nature of risk. Difficulties in anticipating the future mean it will be probable that policies are under or over-priced as a consequence. Anticipation of changing risk is complex for property insurance with the challenges of climate change, natural climate shifts, trends in exposure and shifting vulnerabilities to natural hazards. A more likely outcome is that in a competitive market and under uncertainty, insurers would tend to restrict policies to shorter durations.

- Challenges of risk-based pricing and premium discounts: Without risk-based premiums, and associated premium discounts for risk reduction, multi-year contracts will not provide an appropriate incentive to reduce risk. However, pure risk-based premiums are rare in the general retail insurance market (as described above a number of other parameters are generally considered in the premiums). There are also technical barriers to risk-based pricing and premium discounts for risk reduction (see part Contribute to climate change adaptation by incentivizing policyholders to reduce insured risks via risk-based pricing and contractual terms).
- Mismatch between payback periods and contract duration: To incentivise risk reduction, a longer contract (also tied to a long-term loan) is more beneficial, as the payback period for property-level risk reduction through an insurance premium discount would be often in excess of five to 10 years. To give a simple example, a recent UK study found that replacing the wall plaster of a property with a water resistant material to improve flood resilience would cost around £2,900 (if installed during repair) and would have a payback of £3,400 in the event of an extreme flood (ABI, 2009b). If the probability of an extreme flood were around 1-in-10 (that is, a highly hazard-prone region) then this would amount to a reduction in the technical risk premium of around £340 per year; hence a payback period of 8.5 years. In a lower (but still high) risk region, where the probability of an extreme flood was 1 in 30 years, the payback period would be 25.5 years. To provide a strong incentive, the insurance contract would need to be at least as long as the payback period. But empirical evidence suggests a limit on the term of a multi-year contract of around 5 years (Goss and O'Neill, 2010); however, a European Commission enquiry into business insurance of 2007 found that the average contractual duration across Member States for this market segment is approximately one year and only a small number of national markets had higher contractual durations (EC, 2007).

3.25 Based on results of the public consultation that led to the publication of this report, a majority of stakeholders did not agree that considering long-term insurance contracts could help insurers maintain availability and affordability of insurance in light of climate change. They highlighted that long-term insurance contracts could decrease flexibility and choice for the customers because they would not be easily able to renegotiate contracts or switch to an alternative insurer. As a result, the competition between

insurers could decrease if the policyholder cannot change insurer for the long term. There is also a possibility that during long-term contracts new risks emerge, and the lack of possibility to annually review premiums generates the risk of mispricing which could even lead to insolvency of insurers. As a result, long-term contracts can generate more risk and uncertainty for the insurers and lead to higher premiums for policyholders. The complexity of long-term P&C risk modelling would also increase.

- 3.26 Some pros of long-term contracts were also indicated by respondents e.g. availability of insurance coverage for a longer period and at a locked-in price which could help to avoid cyclical swings in capacity and price following large market events. The stability of the premiums paid annually in multi-year contracts would be assured for policyholders. Additionally, long-term contracts could create partnership between policyholder and insurer.
- 3.27 Development of long-term insurance contracts to deal with climate change could potentially require specific regulatory treatment. Many stakeholders highlighted in their responses to the consultation that multi-year contracts are generally the exception in non-life insurance and that in their view it would require a thorough review of regulation if such contracts became the norm. They referred for example to the calculation of capital requirements based on the standard formula in Solvency II, in which the current approaches regarding cancellation and lapse risks might need to be reconsidered.

Consider in underwriting strategy products and services contributing to climate change adaptation and mitigation

- 3.28 As put forward in EIOPA's Opinion, it is prudentially relevant to require undertakings to take into account the impact of their underwriting activity on sustainability factors. This chapter presents examples of such underwriting practices that aim at mitigating or adapting to climate change. Considering such insurance products or services in the underwriting approach might have the advantage to be visible at sector level and therefore have a broad impact.
- 3.28. As stated previously in this report, the underwriting strategy of the (re)insurer should be consistent with actuarial risk-based principles. Therefore, any decisions and actions taken by (re)insurance undertakings regarding climate change adaptation and mitigation require proper prior risk assessment. This last expectation will require further investigation to develop a common knowledge and understanding of the impact of incentive practices on the risk insured and the overall insurer's exposure to climate-related risks. The development of non-financial disclosure and the EU Taxonomy of sustainable activities can also help with the screening of risks.

- 3.29. The underwriting strategy of an insurer can, for various reasons, also aim at promoting insurance solutions for economic activities which have sustainability objectives or characteristics. It is important that such underwriting activity does not convey a false impression or provides misleading information about how the insurance product would be mitigated or adapt to climate change (“greenwashing”). Also, this should not lead insurers to making underwriting decisions which are not economically viable. Finally, underwriting “green activities” does not mean that the activity does not pose insurance risk, and the insurer should be able to price the risk.
- 3.30. In analogy to stewardship in investments²⁹, such an underwriting strategy may at an initial stage be prompted by reputational considerations. However, its development over time, as well as competition considerations and underwriting practices, can be used as a strategy of differentiation between non-life insurers regarding the consumer preferences for environmental claims in the Single Market³⁰. Over a longer term, where sustainable economic activity proves to support the real economy and the stability of the financial system, sustainable underwriting practices may positively impact the business model of insurers and the risk characteristics of the portfolios.
- 3.31. Insurers can implement various differentiation strategies according to the goal they want to reach. On a shorter term, impact underwriting can be helpful for the insurers to lower their exposures to climate related risks by acting directly on the risks insured, and by reducing the overall climate-related risk exposures of their portfolios. Indeed, impact underwriting practices are supposed to reduce the probability of a damage by incentivizing policyholders not to expose themselves to the risks caused by the consequences of climate changes. Care must be taken not to generate additional risks, though. For instance, the use of more sustainable materials (such as timber or straw) proposed as to ‘build-back-better’ after a property damage could also generate new risks (e.g. fire damage) that insurers might not have taken into account when calculating the indemnification amount or the premium.
- 3.32. The underwriting strategy could also consist in integrating ESG criteria into the underwriting standards and guidelines of the undertaking in order to

²⁹ Stewardship in the context of sustainable finance refers to the means by which undertakings act to influence the strategy and business of the firms in which they are investing in order to progress towards sustainable economic activities. This principle is already recognised in other regulatory action and initiatives. See Directive 2017/828 of 17 May 2017 amending Directive 2007/36/EC as regards the encouragement of long-term shareholder engagement.

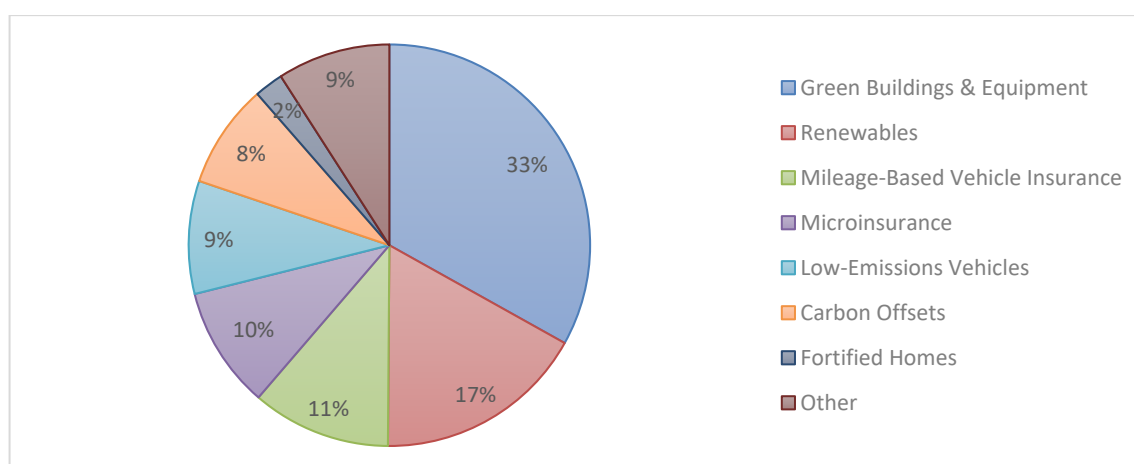
³⁰ The European Commission quoted that more than a half of costumers are influenced by environmental advertising in their decision to purchase, [Consumer Conditions Scoreboard – Consumers at home in the Single Market](#), European Commission, 2019, pp. 11-12.

assess projects and clients before the subscription of any insurance policy (UNEP-FI, 2020). Practices may range from excluding non-sustainable activity (negative screening), as well as promoting adaptation or mitigation behaviour (through positive screening), to outright sustainability-themed underwriting for certain insurers. On a longer term, when such a strategy is implemented, the portfolio should have a lower risk profile.

3.33. Beyond underwriting, insurers could develop related services to provide advice or project studies to utilities or corporate clients, even retail customers, in order to help policyholders to adapt to climate change or to modify their behaviour by encouraging them to lower their greenhouse gases emissions. The positive impacts of these services and advice may be observed over a longer term and indirectly, and are consequently more difficult to assess. No consensus exists on measures and tools to identify, assess and monitor long-term impacts of the climate change-related risks. However, as for stewardship in investments some years ago, impact underwriting can be recognised as positively contributing to climate change mitigation and adaptation while recognising that further work is needed to reach a common understanding on the scope of impact underwriting. Stakeholders responded in the consultation that their preference goes to positive screening rather than negative screening.

3.34. The following table presents types of products available in the international “Climate Smart Insurance Products”³¹ database. The database was developed by the CDI with climate-related insurance products already available to consumers and businesses, as well as information available on companies’ websites. In the CDI database, more than 50% of the products are related to green building & equipment and to renewables.

Figure 2: Type of products available in the Climate Smart Insurance products database.



³¹ https://interactive.web.insurance.ca.gov/apex_extprd/f?p=142:1:6594253590917::NO:::

Table 2: Examples of products aiming to support adaptation and mitigation measures.³²

Type of product	Climate change mitigation or adaptation	What?	Company name
Property insurance	adaptation	Premium credits for homes meeting IBHS fortified standards with respect to coverage for storms.	Travelers ³³
Property insurance	mitigation and/or adaptation	Eco upgrade: replace damaged property and apply modernization measures to buildings including environmentally-friendly equipment, products, and construction materials after the occurrence of damage.	Allianz ³⁴
Motor insurance	mitigation	Pay as you drive insurance, also known as pay per mile insurance, charges you for each mile or hour driven, plus a monthly or annual charge that covers the car against damage or theft while it's parked.	Axa ³⁵
Motor insurance	mitigation	Offers a special motor insurance tariff for customers that hold an annual public transportation pass.	Allianz ³⁶
Motor insurance	mitigation	Premium discounts for "green" or low-emission vehicles (electric, hybrid, gas-powers vehicles which emit less greenhouse gases than standard vehicles).	Generali ³⁷
Crop insurance	adaptation	Multi-peril crop insurance combined with satellite data to create a comprehensive insurance package providing real time data on crop development and possible weather impacts.	Allianz ³⁸

³² Please note that in addition to the examples listed there might be additional companies/examples which could fit the definition of impact underwriting. The intention of this table is just to provide concrete examples on how such products could look like. In addition even if details about these products are not always available from the public information disclosed on insurers' websites, it is assumed that the premiums is based on a proper risk assessment.

³³ <https://www.travelers.com/tools-resources/home/renovation/renovating-your-home-to-fortified-standards>

³⁴ https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/responsibility/documents/2014_GreenSolutions_factsheet.pdf

³⁵ <https://www.axa.lu/en/insurance-km-car>

³⁶ https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/migration/media/press/document/Green-Solutions.pdf

³⁷ <https://www.generali.ch/en/privatkunden/fahrzeuge-reisen/autoversicherung>

³⁸ https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/migration/media/press/document/Green-Solutions.pdf

Warranty insurance	mitigation	Photovoltaic (PV) warranty insurance to increase confidence in the long-term performance and financial attractiveness of PV projects.	MunichRe ³⁹
Renewable energy insurance	mitigation	Customized coverage for private home owners and small to mid-size commercial companies to build renewable energy facilities, such as photovoltaic, solar thermal, biomass and geothermal installations.	Zurich insurance ⁴⁰
Pollution liability insurance	mitigation	Covers loss associated with an existing or new pollution event and includes an embedded Green Remediation supplementary payment. Green remediation includes the increase in costs for following standards, products, methods and processes for improving the environment, increasing energy efficiency and enhancing safety and property protection. This also includes the increase in costs attributable to apply green techniques which operate to minimize waste generation, reduce energy consumption, or conserve natural resources in the execution of a clean-up.	Zurich insurance ⁴¹
Technical risk	mitigation	Insure technical risk for breakthrough technologies in renewable energy production, biofuels, energy storage...	Axa XL ⁴²
Forest insurance	mitigation	Provides forest owners with cover against losses from certain insured perils, e.g. fire, hail, windstorm or landslide.	Allianz ⁴³

3.35. The example of pay-as-you-drive (PAYD) insurance provides a good insight into an underwriting strategy aimed at mitigating climate change as well as the insured risk. Vehicle insurance is generally considered a fixed cost with respect to vehicle use. In many countries, motorists usually receive little or no cost savings when they reduce mileage. In this case, drivers who are similar in other respects—age, gender, location, driving safety record—pay nearly the same premiums if they drive five thousand or fifty thousand

³⁹ <https://www.munichre.com/en/solutions/for-industry-clients/risk-management-for-the-photovoltaics-industry.html>

⁴⁰ <https://www.zurich.com/en/sustainability/working-with-customers>

⁴¹ <https://www.zurich.com/en/sustainability/working-with-customers>

⁴² <https://newenergyrisk.com/>

⁴³ https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/migration/media/press/document/Green-Solutions.pdf

kilometres a year. PAYD pricing converts insurance into a variable cost, where premiums are directly related to annual vehicle mileage. This makes vehicle insurance more actuarially accurate (premiums better reflect each vehicle's claim costs) and gives motorists a new opportunity to save money when they reduce their mileage. It can also help achieve several public policy objectives including increased equity, congestion reduction, road and parking cost savings, road safety, consumer savings, energy savings and pollution reductions. While mileage is one possible metric to approximate desirable driving behaviour, it has to be noted other possibly more sophisticated approaches also exist (e.g. taking into account the driving style).

- 3.36. Bordoff and Noel (2008) estimated that with such a system driving would decline by 8 percent in the US, netting society the equivalent of about \$50 billion to \$60 billion a year by reducing driving-related harms. This driving reduction would reduce carbon dioxide emissions by 2 percent and oil consumption by about 4 percent. They estimate that almost two-thirds of households would pay less for auto insurance, with each of those households saving an average of \$270 per car.
- 3.37. The (re)insurance industry also offers a number of services which could contribute to climate change adaptation or mitigation, as listed in the table below.

Table 3: Examples of services aiming to support adaptation and mitigation measures.⁴⁴

Type of service	Climate change mitigation or adaptation	What?	Company name
Risk engineering	adaptation	Insurance risk engineers help customer to better understand, mitigate and disclose the climate risks at local level (for example with on-site visits).	Zurich ⁴⁵
Tools, mobile application	adaptation	Tools for customers to assess the risks of natural hazards around the world, from the	Munich Re ⁴⁶

⁴⁴ Please note that in addition to the examples listed there might be additional companies/examples. The intention of this table is just to provide concrete examples on how such services could look like.

⁴⁵<https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiHqvfo1NnrAhVnMewKHcWP D2wQFjAMegQIixAB&url=https%3A%2F%2Fwww.zurich.com%2F-%2Fmedia%2Fproject%2Fzurich%2Fdotcom%2Findustry-knowledge%2Fglobal-risks%2Fdocs%2Fzurich-climate-change-whitepaper.pdf%3Fla%3Den&usg=AOvVawOUrM3bAm5Cu7ZQPT9eShtk>

⁴⁶ <https://www.munichre.com/en/solutions/for-industry-clients/nathan.html>

		location-based individual risk through to entire risk portfolios.	
Energy advisory services	mitigation	Offers evaluation reports/assessments to renewable energy manufacturers, including process and product quality management, as well as the review of product certification, clients' track record and project references.	Allianz ⁴⁷
Ad-hoc cat modelling studies	adaptation	With numerical modelling and analysis capabilities, it is possible to develop ad-hoc studies aimed at the quantitative risk assessment of portfolios of buildings/plants, as well as the assessment of potential loss accumulation. The analysis of portfolios of buildings/plants, with interconnections (e.g. supply chain), requires to simultaneously estimate the effect of natural hazards at each location.	Axa ⁴⁸

3.38. Stakeholders, in their answers to the public consultation, also shared experience of practices, which do not refer to clearly identified services or products but could meet the definition of impact underwriting given in this report. Such examples are listed in the table below and will merit further consideration.

3.39. Table 4: Elements of products and services that warrant further consideration in the context of impact underwriting

Type of product or service	Climate change mitigation or adaptation	What?
Property insurance	mitigation	Combination of loss-based insurance indemnification and savings account in a

⁴⁷https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/responsibility/documents/2014_GreenSolutions_factsheet.pdf

⁴⁸ <http://www.axa-matrixrc.com/Documents/ServicesCatalog%20NAT%20HAZ%20CAT%20MODELLING.pdf>

		hybrid product, in order to help policyholders finance eco-friendly materials when it is necessary to rebuild after a loss
Motor insurance	mitigation	Specific covers dedicated to sustainable mobility (e.g. specific insurance for shared vehicles)
Motor insurance	mitigation	Favourable terms in the policy to incentivise the upgrade of a company's fleet to greener vehicles (e.g. full replacement cost for the first few years with no deductible for hybrid cars)
Tools, mobile app	adaptation	Weather alert technologies with insurance policy (customers receive an SMS with a warning and a link to the website, where they can find out, among others how to protect themselves against the negative effects of individual weather event).

Next steps

- 3.40. Climate change brings both risks and opportunities to the (re)insurance sector. (Re)insurers could contribute to climate change mitigation and adaptation through their pricing as well as their underwriting strategy. (Re)insurers can also intervene in many ways before and after extreme events, for example through prevention and awareness campaigns among their policyholders to prevent damage from occurring or to limit the damage once it occurred; contributions to the knowledge of risks and provision of data, models and studies to improve the knowledge of the risks (for both their policyholders and public authorities); raising of public awareness of the new construction standards and techniques that contribute to the resilience of new buildings, etc.
- 3.41. Impact underwriting practices could be an opportunity for insurers to adapt to climate change by reducing the risks and the expected related claims. By incentivizing policyholders' behaviour to take prevention measures and reduce their carbon footprint, insurers will also participate in lowering their overall exposure to climate-related risks. However, impact underwriting needs to be carefully designed. It should not lead to a worsening of the overall protection gap, and greenwashing needs to be avoided. Insurers should be able to assess and justify the expected direct and indirect effects of such practices on the risks covered. Impact underwriting is a nascent field, and more new ideas can be expected in the future.

- 3.42. EIOPA will, in accordance with its Annual Work Plan 2021⁴⁹, through the collection of best practices and engagement with undertakings and stakeholders, identify the concrete areas to further materialise impact underwriting from a prudential and product design perspective, with a focus on climate change adaptation.
- 3.43. Consistently with actuarial risk-based principles, EIOPA will explore the potential appropriateness for a differentiated risk-based Pillar 1 treatment of insurance products related to climate change adaptation, having regard to evidence. EIOPA will also further investigate the potential for long-term non-life contracts, having regard to the need for developing new products to address the challenges posed by climate change. EIOPA will also investigate the potential incorporation of the impact underwriting concept in product design requirements, including through insurance distribution and product oversight and governance requirements.

⁴⁹ <https://www.eiopa.europa.eu/sites/default/files/publications/administrative/eiopa-bos-21-033-revised-single-programming-document-2021-2023.pdf>

Annex: Case studies chosen by the insurance associations

Event	Forest fires from October 14 to 16, 2017 (Portugal)	Heavy rain over Malmö 2014 caused flooding (Sweden)	2013 flood disaster (Germany)
Lobs mostly impacted	Property	Property	Property (building, content and major losses to business interruption).
Insurance scheme	Private insurance sector and by State programs financed by national funds to support the reconstruction of permanent housing and the resumption of production conditions for companies affected with direct losses.	Private insurance sector	The flood was covered by the private insurance sector. There are no national compensations funds in Germany nor a public-private-partnership.
Repricing after the event	No	No	No
Insurance stopped offering coverage	No	No	No
Lessons learned	The fires of 2017 drew the attention of the Government to the low rate of penetration of insurance in housing and to the importance of insurance for commercial and industrial activities. However, the support provided by the State had a negative effect on the public's perception of the importance of insurance, by inducing the idea that it is not worth paying an insurance premium if, in the end, the State ends up helping everyone.	Heavy rain will have a larger impact on insurances in the future and the necessity to adaptation measures to keep the insurance cover.	Insurance sector: The insurance industry has learned to monitor insured risks more closely over the years. Insurers work more closely with the scientific community. Insurers insist on working preventive measures Public sector: After the 2013 flood, politicians understood that building owners and businesses could have taken out comprehensive private insurance. However, many have not done so in the past because the state has regularly paid financial aid following natural disasters. The hope of receiving aid payments has kept the insurance density low. The prime ministers of the 16 German federal states therefore decided in 2017 that financial aid should no longer be paid out in general. Financial aid will only be given to those who have not been able to obtain insurance premiums that are economically viable. The federal states check according to their own criteria whether an insurance premium is not economically viable or not. This check should only be positive in a few cases. We are not aware of any cases in which insurance premiums were assessed as economically not viable.

<p>Impact of climate change</p>	<p>Climate change is expected to have a significant impact on the risk of forest fires in Portugal. In recent years there has been an increasing number of hurricanes and tropical storms hitting Portugal, so the frequency of events similar to Hurricane Ophelia (windstorm associated with a heat wave) is expected to increase.</p>	<p>More flooding to come from heavy rain and in future sea level rise. The sea level might rise 5 meters until 2300. To build close to sea means problem in future, with no insurance and property that will be abandoned.</p>	<p>PIK-GDV Climate study 2011 and update 2016 What was examined? In cooperation with leading climate researchers from the Potsdam Institute for Climate Impact Research, the Free University of Berlin and the University of Cologne, German insurers have linked the weather related losses of the past few decades to different climate models. The main focus was thereby on the most common natural disasters occurring in Germany: storm and hail as well Flood.</p> <p>Questions</p> <ul style="list-style-type: none"> - What damage will natural forces cause in Germany in the future? - What changes does Germany have to adapt to? - What can we do? <p>Storms will become more intense and more frequent in the next decades:</p> <ul style="list-style-type: none"> - A particularly damaging storm event of an intensity like we do every 50 years today experience, can occur every 10 years in the future. The cost of such extreme storms is around 7 to 8 billion euros per storm event. For comparison: German insurers paid for "Kyrill" 2007 their customers "only" 2.4 billion euros. - Storm damage will increase by more than 50 percent by 2100. <p>Flood damage increases:</p> <ul style="list-style-type: none"> - By the end of this century (depending on the scenario) a doubling or even a tripling of the losses is to be expected. - Floods with an intensity that we experience every 50 years on average today can occur every 25 years in the future. <p>Climate study update 2016 The Potsdam Institute for Climate Impact Research (PIK) has updated the study on flooding with the latest climate models. It turns out that our forecast of increasing flood damage five years ago was correct - in the end it was even too cautious. The damage from River flooding could increase even more than previously expected. Without corresponding adaptation measures, the annual damage costs in Germany could currently be multiply around 500</p>
--	--	--	---

			<p>million euros in the future. Without adaptation measures, damage costs should also be significantly higher than originally assumed.</p> <p>For further information please refer to: https://www.nat-hazards-earth-syst-sci.net/16/1617/2016/ https://www.nat-hazards-earth-syst-sci.net/14/3151/2014/ https://www.gdv.de/de/themen/news/schadenszenarien-bis-zum-jahr-2100-13822</p>
<p>Future role of insurance industry</p>	<p>The insurance industry should rethink the frequency of such events and new reinsurance solutions. Insurers should also take an active role in fire prevention, particularly in the underwriting phase by promoting the use of more resistant and suitable building materials.</p>	<p>The insurance industry have a role to offer insurances to consumers and SMEs, but can be limited to do so if not proper adaption is done by responsible stakeholders.</p>	<p>The impacts of loss and damage associated with climate change can set back development by potentially increasing not only the incidence, but also the severity of an economic downturn. By compensating for damages caused by extreme weather events and – at the same time – demanding prevention measures to reduce risks associated with extreme weather events, insurers help individuals and businesses break out of the vicious circle of "damages followed by increasing insurance premiums". Insurers actions can significantly reduce the vulnerability of a society and contribute to a long-term social and economic well-being, especially as part of a menu of options to incentivize risk aware behaviour.</p> <p>With the advancing climate change, extreme weather events and catastrophe losses are likely to increase in the future. Insurers have the tools to reduce the catastrophic effects of disasters, enable timely recovery and contribute to a sustainable, climate-adapted development:</p> <ul style="list-style-type: none"> - By assessing risks and potential losses, the insurance industry can support climate risk management with the following measures: Map, analyse, prioritize and evaluate risks (risk-based pricing). - By reducing vulnerability and incentivizing risk-preventive behaviour, insurance helps to increase resilience. - Insurance also helps to create security for investments and planning in climate protection and adaptation. This enables sustainable

			<p>investments in future-oriented sectors such as renewable energies.</p> <ul style="list-style-type: none">- Insurance offers reliable and timely financial compensation for loss events and thus offers security in the aftermath of a disaster.
--	--	--	--

Abbreviations

AAE – Actuarial Association of Europe

ABI - Association of British Insurers

APS - Portuguese Association of Insurers

BEUC - European Consumer Organisation

BIS – Bank for International Settlements

CDI – California Department of Insurance

COM – European Commission

DKKV – German Committee for Catastrophe Prevention

DRR - Disaster Risk Reduction

EEC – European Economic Community

ESG – Environment, Sustainability and Governance

EIOPA – European Insurance and Occupational Pensions Authority

EU – European Union

GDV - Gesamtverband der Deutschen Versicherungswirtschaft

GHG – Greenhouse gases

IBHS – Insurance institute for Business and Home Safety

I4CE - Institute for Climate Economics

JRC – Joint Research Center (EU)

NFIP - National Flood Insurance Program (USA)

OECD - Organisation for Economic Co-operation and Development

PAYD – Pay-As-You-Drive

P&C – Property and Casualty insurance

RCP - Representative Concentration Pathways

TEG – Technical Expert Group (EU Green Taxonomy)

UNEP FI – United Nations Environment Programme Finance Initiative

UK – United Kingdom

References

ABI (2009b) Resilient Reinstatement: The Costs of Flood Resilient Reinstatement of Domestic Properties, ABI Research Paper. No 14, London.

BIS (2020). The green swan - Central banking and financial stability in the age of climate change.

Bordoff, J. and Noel, P. (2008). Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity. The Brookings Institution.

Botzen, W. and van den Bergh, J. (2012a). Risk attitudes to low-probability climate change risks: WTP for flood insurance. *J Econ Behav. Organ.*, 82(1):151-166

Botzen, W. and van den Bergh, J. (2012b). Monetary valuation of insurance against flood risk under climate change. *Int Econ Rev* 53(3):1005-1025

Botzen, W., et al. (2013). Framing the risk and preferences for annual and multi-year flood insurance, *J. Econ. Psychol.*, 39, 357-375.

Bräuninger, M. et al. (2011). Application of economic instruments for adaptation to climate change, Final Report, Perspectives Climate change.

CDI (2017). The Availability and Affordability of Coverage for Wildfire Loss in Residential Property Insurance in the Wildland-Urban Interface and Other High-Risk Areas of California: CDI Summary and Proposed Solutions.

Charpentier, A. (2008). Insurability of Climate Risks, *The Geneva Paper*, 33, 91-109.

COM Expert Group (2014). Final Report of the COM Expert Group on European Insurance Contract Law.

CRO Forum (2020) Carbon footprinting methodology for underwriting portfolios <https://www.thecroforum.org/2020/05/01/carbon-footprinting-methodology-for-underwriting-portfolios/>

Den, X. et al. (2017). Insurance of weather and climate-related disaster risk: Inventory and analysis of mechanisms to support damage prevention in the EU.

DKKV (2015). Das Hochwasser im Juni 2013, Bewaehrungsprobe fuer das Hochwasserrisikomanagement in Deutschland, Deutsches Komitee Katastrophenvorsorge e. V., Universitaet Potsdam.

EIOPA (2019a). Opinion on Sustainability within Solvency II, EIOPA-BoS-19/241, Frankfurt am Main, 30 September 2019.

EIOPA (2019b). Staff discussion paper: Protection gap for natural catastrophes, 1 Sept. 2019.

EIOPA (2019c). Big data analytics in motor and health insurance: a thematic review.

European Commission (2007) Sector Inquiry under Article 17 of Regulation (EC) No 1/2003 on business insurance (Final Report) (September), SEC (2007) 1231.
https://ec.europa.eu/competition/sectors/financial_services/inquiries/final_report_annex.pdf

Goss, R. and O'Neill, D. (2010). Long-term retail general insurance: The potential for long-term home insurance contracts in the context of flood risk, ABI Research Paper No. 21, London.

JRC, (2020). Peseta IV – Climate change impacts and adaptation in Europe.

Klein, R. (2007). Catastrophic Risk and the Regulation of Property Insurance: A Comparative Analysis of Five States. Working Paper, Georgia State University, December.

Kleindorfer, P., et al. (2012). Single-Year and Multi-Year Insurance Policies in a Competitive Market.

Kousky, C. (2017). Financing Flood Losses, A Discussion of the National Flood Insurance Program, Resources for the Future, University of Pennsylvania.

Kunreuther, H. and Michel-Kerjan, E. (2015). Demand for fixed-price multi-year contracts: Experimental evidence from insurance decisions. *Journal of Risk and Uncertainty*, 51 (2), 171-194.

Lamond, J. and Penning-Rowsell, E. (2014). The robustness of flood insurance regimes given changing risk resulting from climate change. *Climate Risk Management* (2014) 1–10.

Maynard, T. and Ranger, N., (2012). What Role for “Long-term Insurance” in Adaptation? An Analysis of the Prospects for and Pricing of Multi-year Insurance Contracts. *The Geneva Papers on Risk and Insurance - Issues and Practice* volume 37, pages318–339(2012)

McAneney, J. et al. (2016). Government-sponsored natural disaster insurance pools: A view from down-under. *International Journal of Disaster Risk Reduction*, Volume 15, March 2016, Pages 1-9.

Munich Re (2019). Climate change increases wildfire risk in California.
<https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/climate-change/climate-change-has-increased-wildfire-risk.html>

OECD (2018). The Contribution of Reinsurance Markets to Managing Catastrophe Risk.

Paudel, Y. A (2012). A Comparative Study of Public—Private Catastrophe Insurance Systems: Lessons from Current Practices. *Geneva Pap Risk Insur Issues Pract* 37, 257–285 (2012). <https://doi.org/10.1057/gpp.2012.16>

Priest, S., et al. (2016). Promoting adaptive flood risk management: the role and potential of flood recovery mechanisms. *E3S Web Conf.*, 7, 17005, <https://doi.org/10.1051/e3sconf/20160717005>, 2016.

Schwarze, R. and Wagner, G.G. (2007). The political economy of natural disaster insurance: lessons from the failure of a proposed compulsory insurance scheme in Germany. *Eur. Env.*, 17: 403-415. doi:10.1002/eet.456.

Seifert, I., et al. (2013). Influence of flood risk characteristics on flood insurance demand: a comparison between Germany and the Netherlands, *Nat. Hazards Earth Syst. Sci.*, 13, 1691-1705.

Seifert-Dähnn, I. (2018). Insurance engagement in flood risk reduction – examples from household and business insurance in developed countries. *Nat. Hazards Earth Syst. Sci.*, 18, 2409–2429 Dealing with flood damages: will prevention, mitigation, and ex post compensation provide for a resilient triangle?, *Ecol. Soc.*, 21, 1, <https://doi.org/10.5751/es-08592-210401>.

South Carolina Department of Insurance (2016). Homeowners Mitigation Credits. Columbia: South Carolina Department of Insurance.

Surminski, S. et al. (2015). Reflections on the current debate on how to link flood insurance and disaster risk reduction in the European Union. *Natural Hazards*. ISSN 0921-030X

TEG (2020). EU Technical Expert Group on Sustainable Finance, Taxonomy Final Report, March 2020.

Tesselaar, M. et al. (2020). Impacts of Climate Change and Remote Natural Catastrophes on EU Flood Insurance Markets: An Analysis of Soft and Hard Reinsurance Markets for Flood Coverage. *Atmosphere* 2020, 11(2), 146. <https://doi.org/10.3390/atmos11020146>.

UNEP-FI (2020). Managing environmental, social and governance risks in non-life insurance business.

Vitelo, P. (2007). Hurricane Fears Cost Homeowners Coverage, *New York Times*, October 16.

EIOPA

Westhafen Tower, Westhafenplatz 1

60327 Frankfurt – Germany

Tel. + 49 69-951119-20

info@eiopa.europa.eu

<https://www.eiopa.europa.eu>