CLIMATE FINANCIAL RISK FORUM

CLIMATE FINANCIAL RISK FORUM GUIDE 2021

# SCENARIO ANALYSIS

October 2021

# Contents

This chapter represents the output from the cross-industry Scenario Analysis Working Group of the Prudential Regulation Authority and Financial Conduct Authority's Climate Financial Risk Forum (CFRF). The document aims to promote understanding, consistency, and comparability by providing guidance on how to use scenario analysis to assess financial impacts and inform strategy/business decisions.

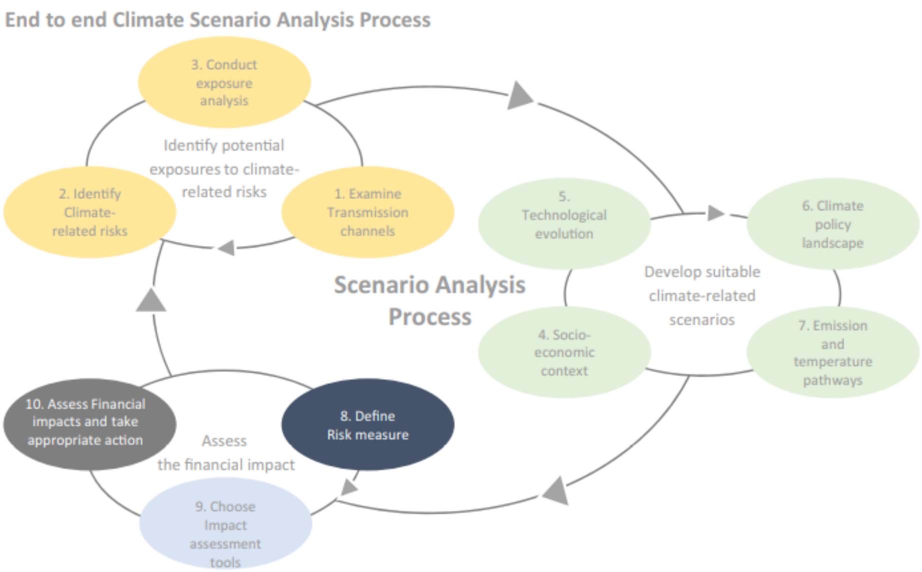
# 1. Introduction

## Purpose

This chapter has been written by a cross-industry working group under the auspices of the Climate Financial Risk Forum (CFRF). It provides practical guidance on how to use scenario analysis to assess climate-related financial risks to inform firms' strategy and business decisions.

The content is aimed at banks, asset managers and insurers of all sizes, and may be of interest to other institutions, such as pension schemes. It describes current industry practice based on the results from the Global Association of Risk Professional's (GARP) Climate Risk Management Survey undertaken in Q2 2021.

This chapter builds on the previous CFRF Scenario Analysis Chapter included in the 2020 Guide and in particular, the iterative end-to-end climate scenario analysis process set out in that Chapter.




It provides further guidance for specific bank, insurance, and asset management use cases on how to identify potential exposures to climate-related risks and assess their financial impact using the latest scenarios developed by the Central Banks and Supervisors Network for Greening the Financial System (NGFS); as well as how to use scenario analysis to measure portfolio alignment with the Paris agreement and to aid portfolio construction.

Although we have presented the banks, insurers and asset managers use cases separately, we do recommend that all firms, regardless of their industry, consider the approaches set out in all these case studies as the principles discussed in the banking section may still be useful for insurers and asset managers and vice versa. Whichever use case is being considered, it is important to ensure that the uncertainties and limitations associated with climate scenario analysis are well understood and clearly communicated when presenting the results to ensure they are interpreted and used appropriately.

This chapter should be read in conjunction with the output from other cross-industry working groups of the CFRF, in particular the Risk Management and Disclosure chapters, as well as the Climate Data & Metrics Report.

**"Without a sound understanding of risk, there can be no effective action. Climate scenario analysis is a powerful tool for firms to better understand their climate risks and this practical guide will help firms take their analysis to the next level."**

**Guus Schoorlemmer**
(Interim Group CRO of Aviva and Chair of CFRF Scenario Analysis Working Group)

## Scope

This chapter is organised into six main sections:

- **Section 2** covers the results of the GARP global Climate Risk Management Survey. This provides valuable benchmarking information; and gives a useful snapshot of the range of practices across the financial system and the challenges and barriers that firms are facing.
- **Section 3** explores key elements to consider when conducting climate scenario analysis and provides an overview of the NGFS scenarios published in June 2021. This section also highlights some of the key challenges facing the user of scenario analysis.
- **Sections 4 & 5** consider how to evaluate transition and physical risks' impacts for banks, insurance companies and asset managers using scenario analysis.
- **Section 6** focuses on the use of scenario analysis to explore alignment of financing portfolio(s) with the objectives of the Paris Agreement. It also provides guidance on how utilising scenario analysis can aid portfolio construction.
- **Section 7** sets out potential areas for future developments.

We have consciously chosen to focus on transition and physical risks in this guide rather than litigation risk.

## 2. Climate scenario analysis in financial firms

Climate scenario analysis is new for many firms, presenting distinctive challenges, such as access to the required data, modelling and resourcing. GARP promotes best practice risk management globally. But with climate-related risk, the market and expectations are fast moving, making it difficult for firms to understand the status of emerging practices or how good their own approaches are.

In 2019, the GARP Risk Institute ran its first global Climate Risk Management Survey ('Survey'). For participating firms, it provided valuable benchmarking information; for others, it gave a useful snapshot of the range of practice across the financial system and the challenges and barriers that firms were facing. The 2020 Survey mapped out the continuing journey and the 2021 Survey showed evidence of a growing sophistication and improvement in the quantification of climate-related risks.

This section presents results of a deep dive on the maturity of climate scenario analysis practices in financial firms, based on the results from GARP's Climate Risk Management Survey undertaken in Q2 2021. The 2021 survey comprised: 47 banks or building societies; 20 asset managers and 11 other firms (insurers, financial market infrastructure). Collectively, they have around $46 trillion of assets on their balance sheets, manage assets of close to $50 trillion and account for about $3.3 trillion in market capitalization. The firms in the survey operate and assess their climate-related risks in all regions of the world. Of these 78 firms, 55 (around 70%) reported that they have undertaken climate scenario analysis. The analysis presented in this deep dive focuses on the practices at these 55 firms; any percentages presented are of a total population of 55 firms, unless otherwise stated.

### Key takeaways

- **Motivation:** The most popular reasons for undertaking climate scenario analysis is to identify risks and assess the financial impacts of climate change. Firms are also using it to support strategy and business development, improve disclosures and assess portfolio alignment.
- **Frequency:** Climate scenario analysis is more frequently used on an ad hoc basis than regularly, and the vast majority of firms have undertaken climate scenario analysis within the last two years.
- **Scenarios used:** Firms chose scenarios for many reasons, but frequently because they covered both risks that could arise if the Paris Agreement objectives are met as well as if these objectives are not met (e.g. there is no change to current policies and the business environment). Popular reference scenarios were those published by the Intergovernmental Panel on Climate Change (IPCC), NGFS and the International Energy Agency (IEA). Just under half the firms use a 'baseline' scenario, often as a counterfactual against which to assess particular impacts.
- **Scope of analysis:** Firms often focus their attention on the most material exposures or those areas of the business that are expected to be the most impacted.
- **Outcomes**: Financial firms are using scenario analysis to help evaluate and take action, such as whether there should be changes in the firm's risk management, portfolio composition, disclosures, and organisational strategy.
- **Building capacity:** Many firms are using external parties to help them develop and build scenario analysis capability. Nearly 80% of firms in the GARP survey's entire sample (of 78 firms) intend to use third party technology and/or data.

## Detailed survey findings

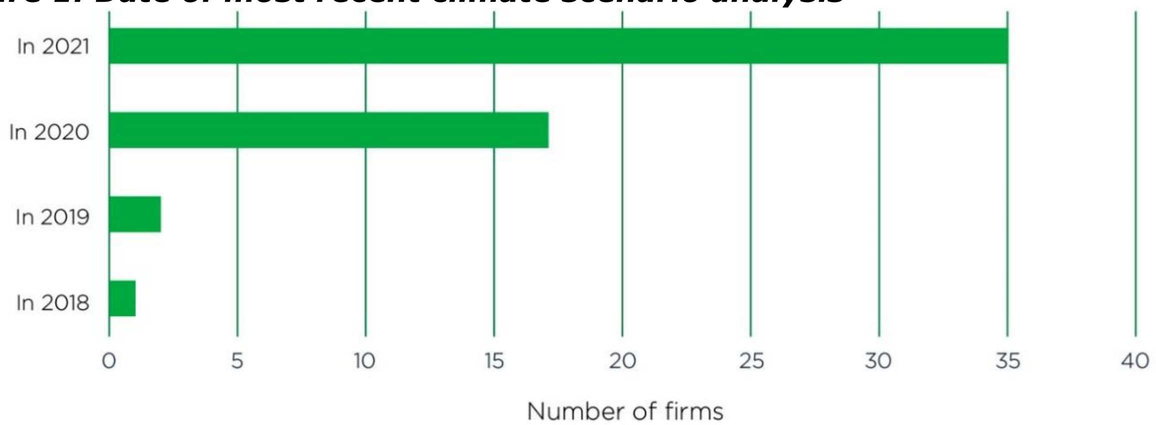
The rest of this section looks at the uses of scenario analysis in financial firms, how firms have used scenario analysis to evaluate and take action as well as how they are planning on building capability.

### Use of climate scenario analysis

Survey participants were asked a number of questions about their use of climate scenario analysis, including if they had ever used scenario analysis, whether they used it regularly or just on an ad hoc basis, and the reasons for undertaking the analysis.

26 firms reported that they use it regularly, with 38 using it on an ad hoc basis (of which 9 firms use it on both bases). Of course, 'regularly' does not necessarily translate to a high frequency of analysis: one firm, for example, reported using it 'regularly', and yet the most recent time they had undertaken climate scenario analysis was in 2018. Judging by the spread in Figure 1, this is quite rare: 35 firms had undertaken scenario analysis in 2021, with a further 17 in 2020.

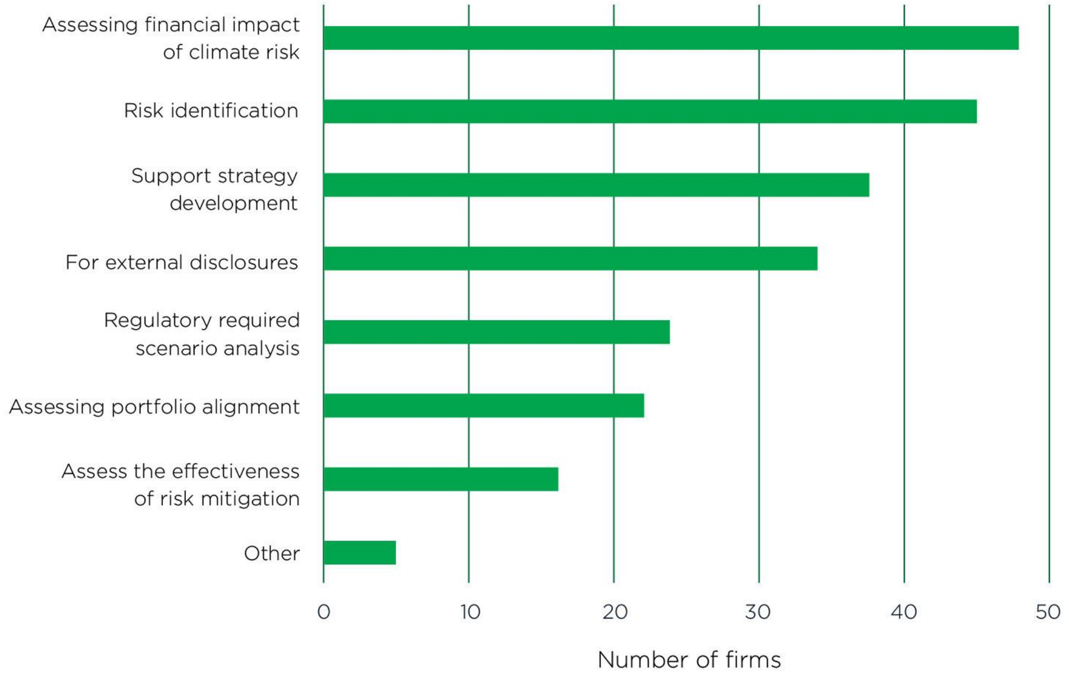
***Figure 1: Date of most recent climate scenario analysis***




Firms reported a range of reasons for undertaking climate scenario analysis (Figure 2). The most popular reasons were risk identification and to assess the financial impacts of climate change. Firms also use scenario analysis to support their strategy development as well as to feed into external disclosures.

Moreover, scenario analysis is also used to assess the alignment of portfolios to a pathway, such as achieving "Net Zero" emissions or being consistent with a particular temperature warming (e.g. 2°C). The reasons noted under "other" included assessing capital adequacy, assessing their firm's resilience to climate change, and building capability for a regulatory stress test.

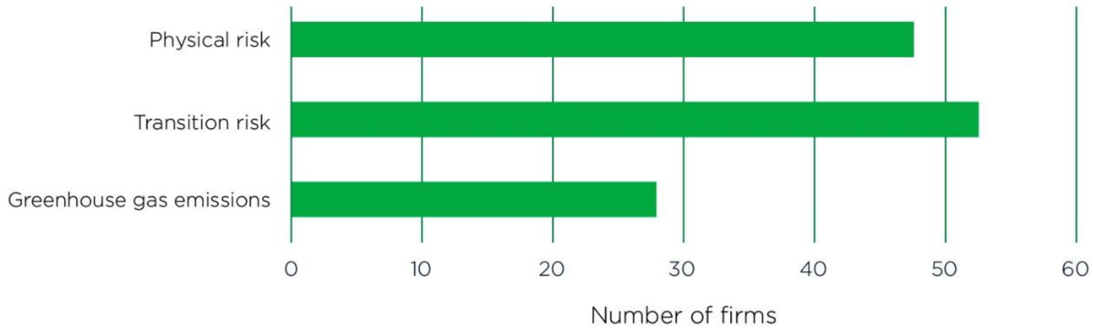
***Figure 2: Reasons for undertaking scenario analysis***




Firms were asked what their risk focus was when using scenario analysis (Figure 3). Most of the firms (52 out of 55) reported that they were assessing transition risk, with 47 firms noting that they assess physical risk. Greenhouse gas (GHG) emissions were assessed by only 28 firms. Although GHG emissions are commonly viewed as a rough proxy for exposure to transition risk, they do not capture all the potential effects of the transition to a low carbon economy.  Moreover, there are difficulties in getting reliable data on emissions across all counterparties, and even more difficult to get reliable profiles of future emissions, which is most relevant for assessing transition risk or alignment to a particular scenario.

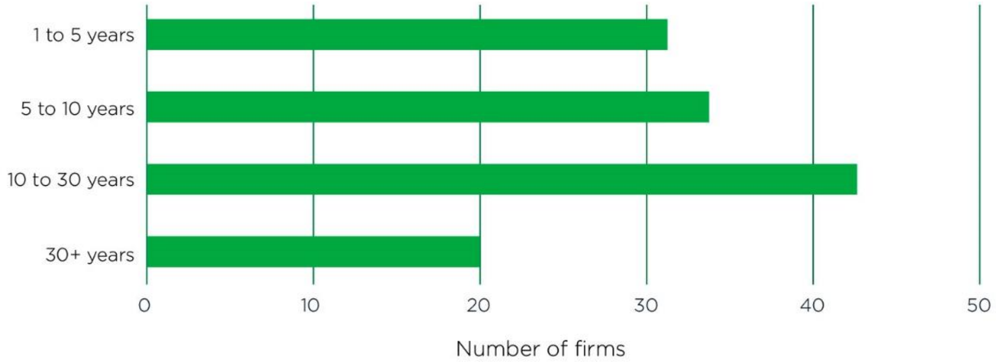
Sections 4 and 5 of this chapter considers the two most popular risk focus areas, transition and physical risks impacts, for banks, insurance companies and asset managers.

***Figure 3: Focus of assessment***



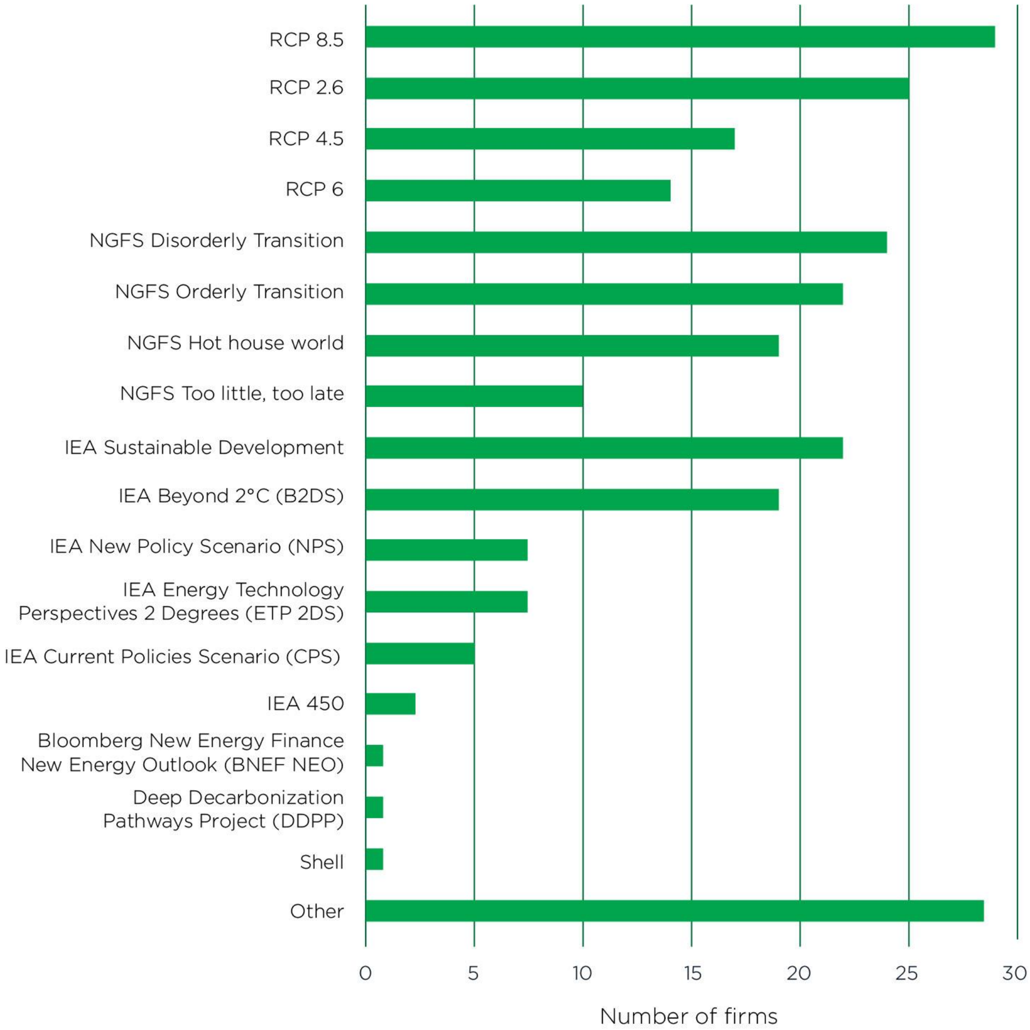

As Figure 4 shows, the most popular time horizon for the scenarios used was 10 to 30 years. The longer time scales tend to be needed for physical risk assessments.

*Figure 4: Time horizon of scenarios used*




Firms can choose to use reference scenarios provided by third parties or to develop bespoke ones suited for a particular business. Figure 5 shows the range of scenarios used by the firms in this year's survey. The "other" category tended to cover bespoke scenarios, which collectively was the second most popular choice.

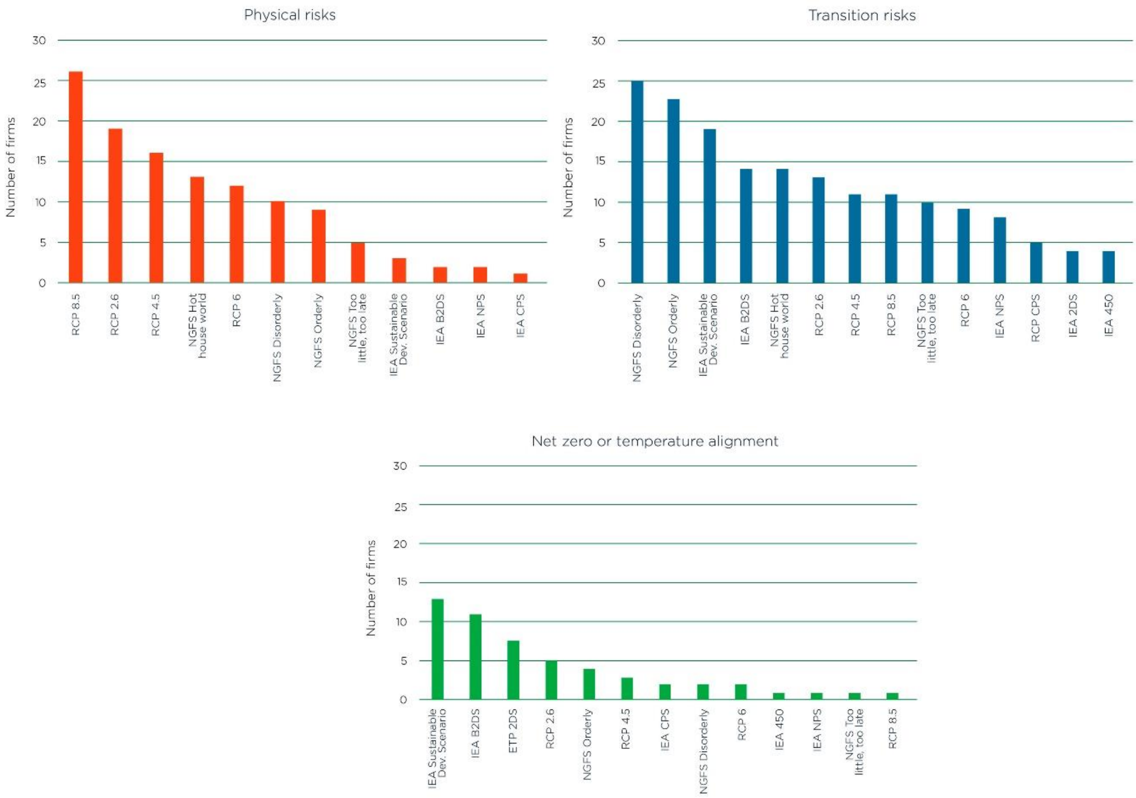
*Figure 5: Climate scenarios used by financial firms*




Firms use distinct scenarios for assessing different risks (Figure 6). The most popular scenarios for assessing physical risk are the IPCC's Representative Concentration Pathways (RCP 8.5, 2.6 and 4.5), followed by the NGFS Hot House World scenario. For transition risk, the most popular scenarios are the NGFS orderly and disorderly scenarios, followed by the IEA Sustainable Development scenario. Fewer firms are using scenario analysis for assessing alignment to a particular temperature trajectory, but the most popular scenarios for this purpose are the IEA sustainable development and the IEA Beyond 2°C (B2DS) scenarios, followed by the IEA Energy Technology Perspectives 2 Degrees scenario (ETP 2DS). For a useful guide to these different reference scenarios, please refer to Annex 2 of the CFRF's 2020 [Scenario Analysis Chapter].

Section 3 of this chapter provides an overview of the latest NGFS scenarios and sections 4 and 5 consider how to use scenario analysis to evaluate transition and physical risks for banks, asset managers and insurers. Section 6 includes a case study on use of scenario analysis with respect to alignment of portfolios to a particular temperature trajectory.

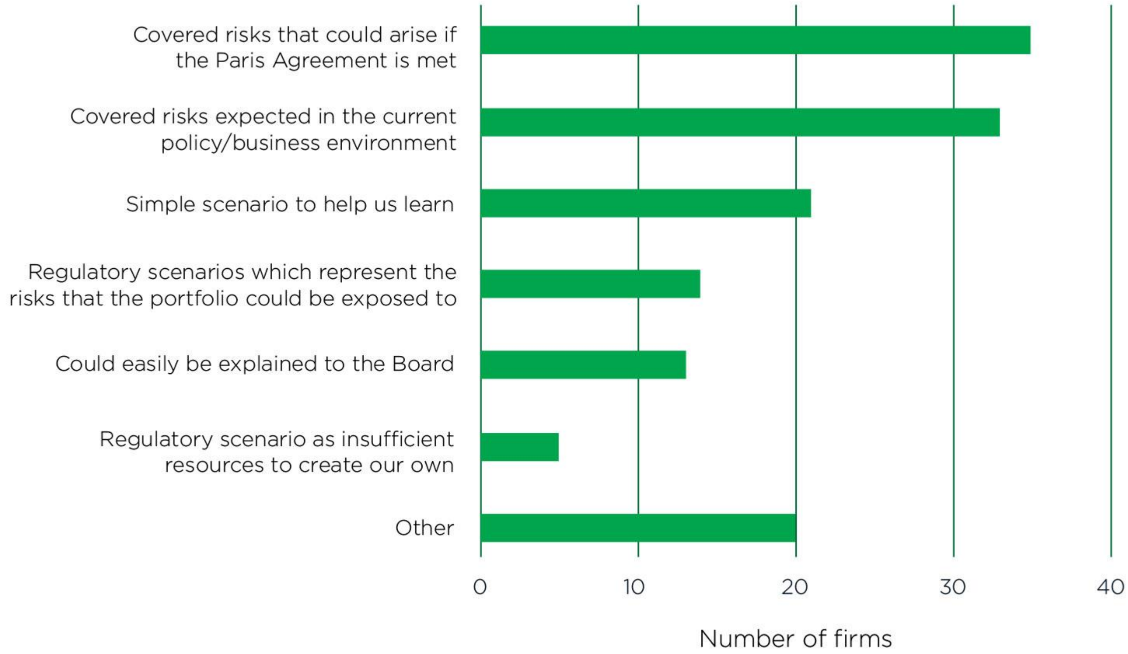
***Figure 6: Most common scenarios used by purpose***




There were a number of motivations for choosing a particular scenario (Figure 7). Covering the risks that could arise if the Paris Agreement objectives are met was the most common reason. Almost as common were scenarios where these objectives are not met, covering the risks that were expected if the current policy and business environment remain unchanged. Given the complexity of undertaking this type of analysis, it is perhaps not surprising that firms also chose scenarios that were simple, to help them learn.

Firms in the survey also noted a range of "other" reasons for choosing scenarios. These covered a range of motivations, such as climate scenarios set by supervisors, using sector specific pathways, insurance-related scenarios, as well as a desire to use internally developed scenarios and bespoke scenarios developed by consulting firms.

***Figure 7: Reasons for choosing scenarios***



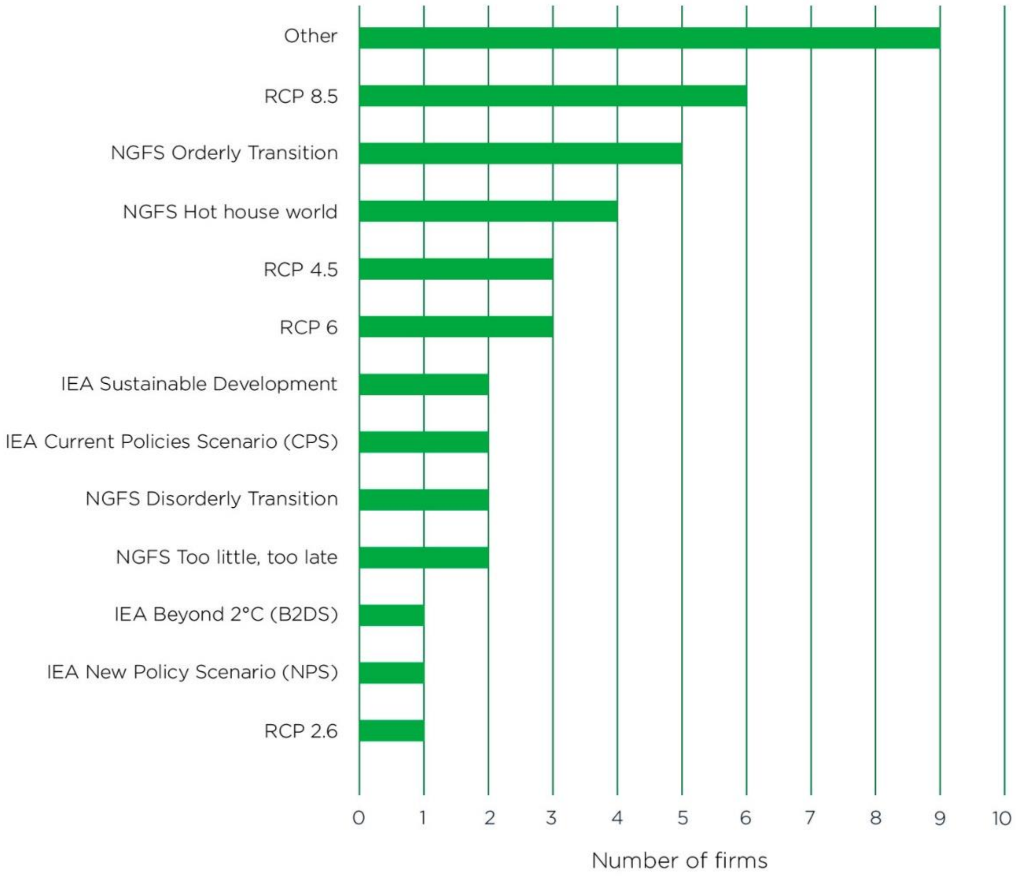

Firms might choose to run a scenario as a "baseline" against which to assess particular impacts. There is no established definition of a baseline, but a common approach is to define it as a scenario in which no mitigation policies/measures are implemented beyond those that are already in force and/or are legislated or planned to be adopted. Based on the insights from the GARP survey, the use of baseline scenarios is not yet well established across all firms. Out of 44 firms that responded to this question, only 20 reported that they did use a baseline scenario. Section 3 of this chapter explores some key elements to consider when conducting scenario analysis including defining a "baseline" scenario.

Figure 8 shows the relative popularity of using different scenarios as baselines. The RCP 8.5 (a high physical risk scenario) is the most popular choice and can be useful as a baseline against which to assess the impact of other scenarios - such as those with lower physical risk and/or higher transition risk. The second most popular, the NGFS Orderly scenario, can be a helpful benchmark against which to compare with a less orderly transition or perhaps a higher physical risk scenario.

As with the data shown in Figure 8, a number of firms use "other" scenarios as baselines. These cover a range of practices including:

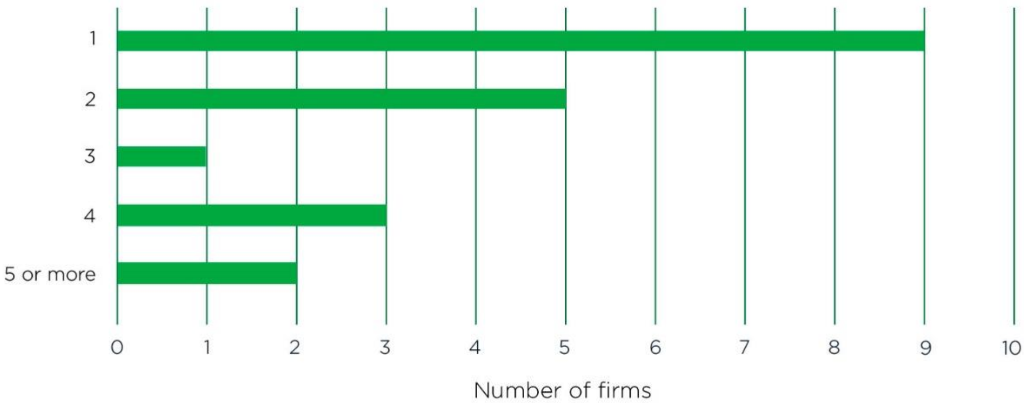
- Using their baseline company forecast,
- A science-based target scenario consistent with 1.5°C warming,
- A scenario based on Nationally Determined contributions, and
- A scenario capturing current climate conditions.

***Figure 8: Choice of baseline scenario***




Whichever baseline scenario is chosen, it is important to recognise that this will affect the interpretation of the results. For example, transition risk will be emphasised if they are judged relative to a baseline scenario with high physical risk/low transition risk, such as RCP 8.5.  Some firms use multiple baseline scenarios, depending on the focus of their analysis (Figure 9). Most common is to use only one, but practice does vary.

***Figure 9: Number of baseline scenarios used***

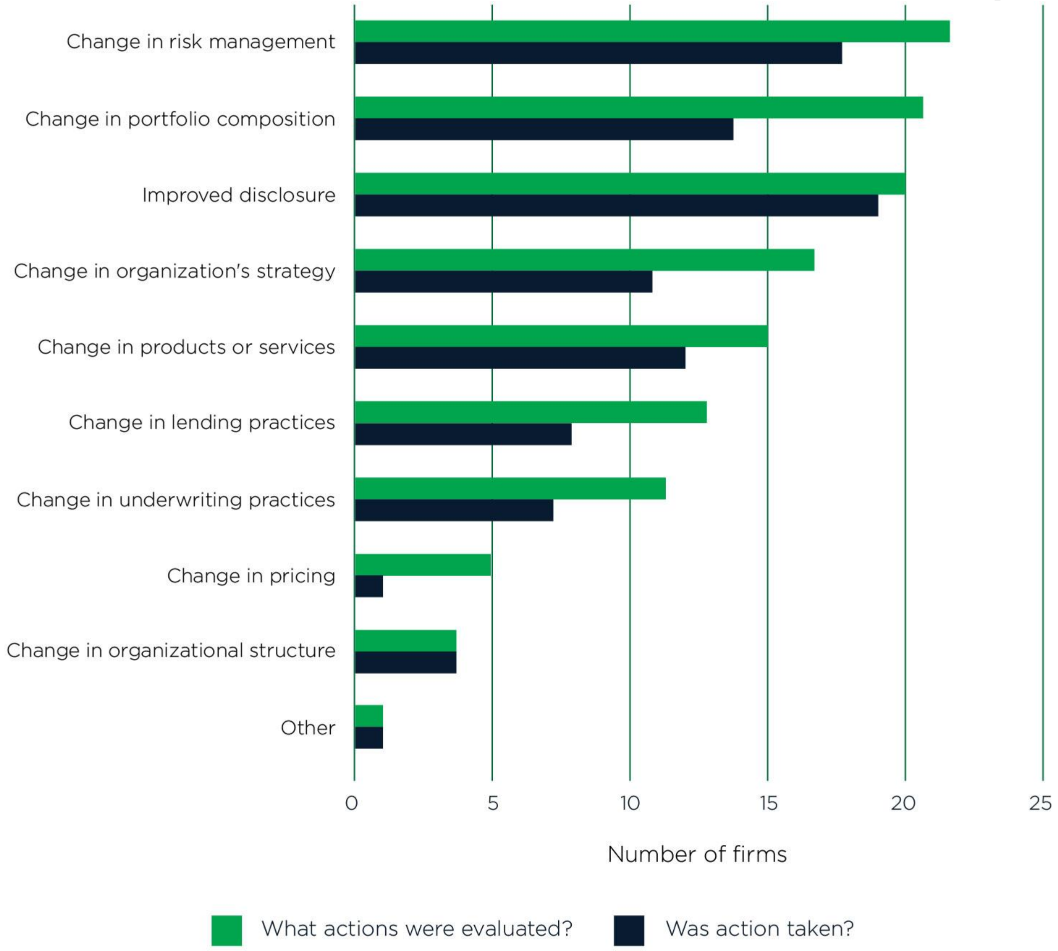



Firms also have to decide on the scope of their analysis: for example, do they cover the entire portfolio or balance sheet, or focus attention on high priority areas? As Figure 10 shows, just over 80% of the firms focus on the most material exposures or portfolios, just marginally more than those citing climate-related risk considerations (e.g. highly vulnerable portfolios).

***Figure 10: Factors driving decision on scope of scenario analysis***


Scenario analysis is not an end in itself. Firms are increasingly evaluating actions on the back of the analysis, which then can lead to actions. The most common actions to be evaluated were whether there should be changes in the firm's risk management, portfolio composition, disclosures, and organisational strategy (Figure 11). Section 6 includes a case study on how utilising scenario analysis can aid portfolio construction. The most common area where action was actually taken was to improve disclosures (at 20 firms), closely followed by a change in risk management (18 firms).

***Figure 11: Actions evaluated and taken as a result of scenario analysis***

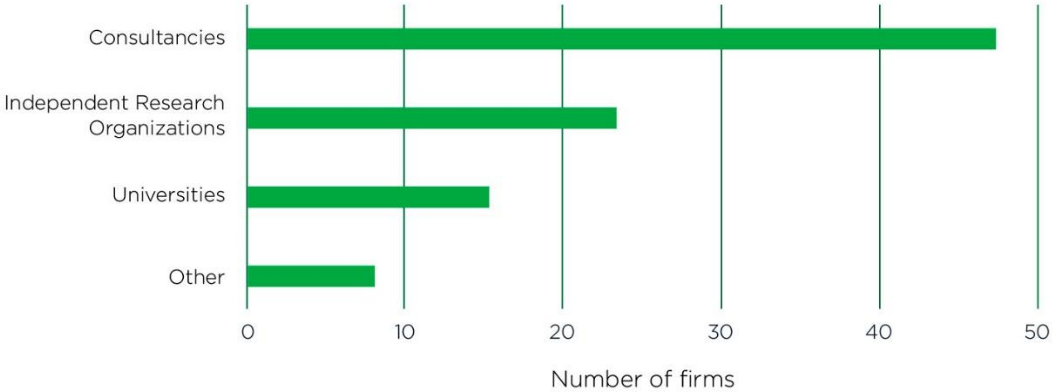


**Resourcing and capacity building**

For many firms, climate scenario analysis is an emerging discipline, requiring new skills, data, methodologies, and time to build infrastructure. Given the pace of change, and the emergence of regulatory requirements, many firms are turning to external parties to accelerate their progress in this area. Indeed, only 21 firms use their own stress testing infrastructure, indicating the difficulty of integrating the new requirements within existing IT and modelling environments.

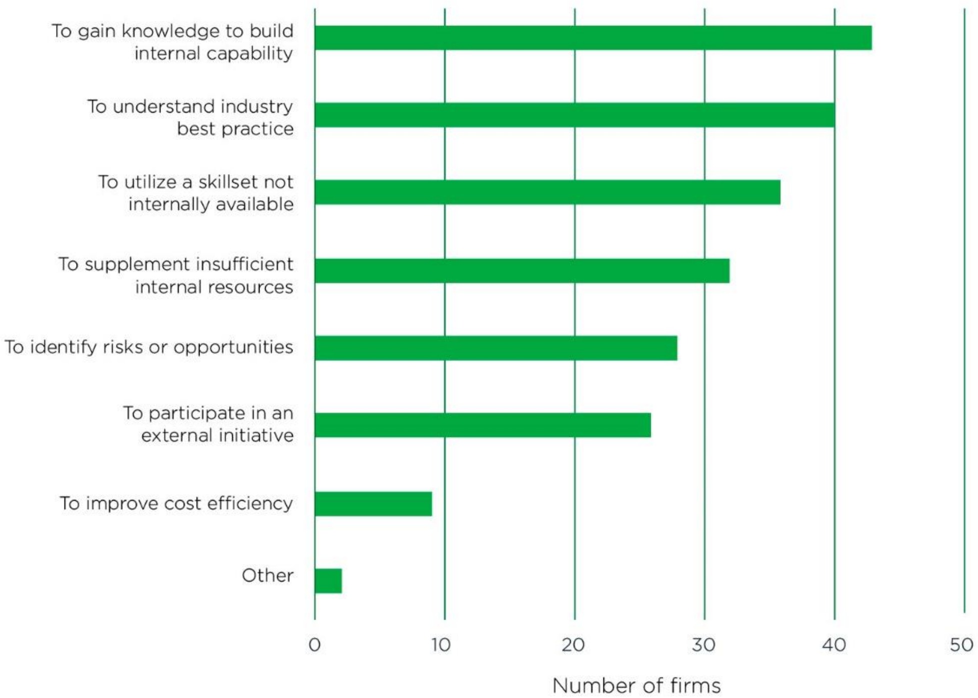
Most firms plan to partner with external organisations to undertake scenario analysis. As depicted in Figure 12, consulting firms are the most popular partners, cited by 48 firms, followed by independent research organisations (22) and universities (15).

***Figure 12: External firms partnering with financial firms to build scenario analysis capabilities***




There are a host of reasons why firms might choose to partner with these firms (Figure 13). Gaining knowledge and building internal capability was the most popular reason cited in the GARP survey (43 firms), closely followed by a desire to understand industry best practice (40 firms). At present, improving cost efficiency is not a particularly strong driver.

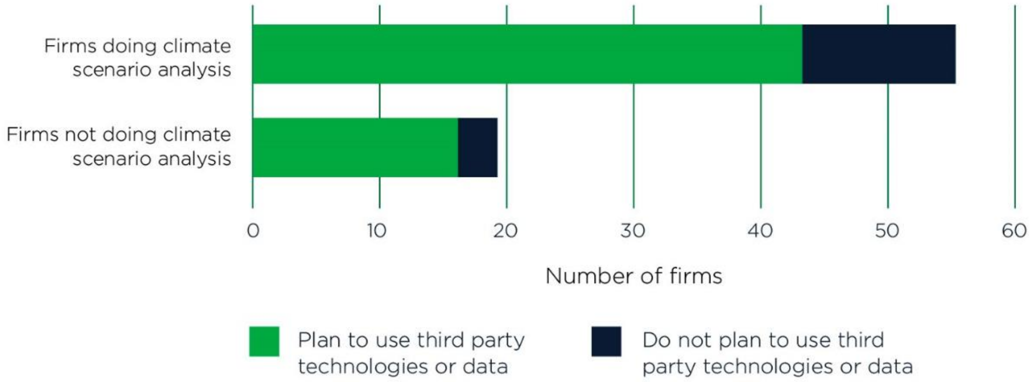
***Figure 13: Reasons for partnering with external parties***



Around three quarters of the firms expect these relationships to be a short-term feature (less than five years) of their organization's approach to climate-related risks. But the picture is made more complex by firms with multiple relationships of differing expected length.

One area where there is a clear message is that there is expected to be a significant use of specialist third-party technology or data support, as opposed to the more general third-party support outlined in **Error! Reference source not found.**. Over 80% o f the firms currently undertaking scenario analysis are expecting to use this. And an even larger percentage of the firms not currently doing scenario analysis do intend to use third party technology or data (Figure 14).

***Figure 14: Planned use of third-party technology or data***




## Overall survey messages

Climate scenario analysis is new for many firms, requiring new skills, data, methodologies, and time to build the relevant infrastructure. But it is also a fast-evolving area, with increasing focus from a broad range of stakeholders who want to better understand financial firms' vulnerabilities to the risks arising from climate change, as well as the implications of various strategic 'alignment' choices.

The GARP deep dive provides insight into the range of practice and the challenges involved in undertaking climate scenario analysis. It illustrates the reasons for undertaking the analysis, from risk identification and quantification to supporting strategy, improving disclosures, and assessing portfolio alignment. Most encouragingly, given that scenario analysis should not be an end in itself, firms report that they are using the analysis to evaluate and take action.

Given the pace of change, and the emergence of regulatory requirements, many firms are working with external parties to expedite their progress and build capability. Although firms still have a lot more work to fully establish climate scenario analysis practices, it is interesting to note that it is the category within GARP's survey that has improved the most since the inaugural survey in 2019.The remainder of this report focuses on a number of practical use cases based on the findings of the GARP survey that financial institutions can learn from or apply.

# 3. Climate scenario analysis key considerations

Last year's CFRF Scenario Analysis Chapter set out the iterative end-to-end climate scenario analysis process – from identifying potential exposures, to developing relevant scenarios, and then to assessing the financial impacts. All this needs to be well governed, with firms learning the lessons as they undertake the analysis to ensure continuous improvement.

In this section, we focus on some elements of that framework where the GARP survey highlighted there is a wide range of different practices, namely the choice of a baseline scenario and selection of scenarios to analyse transition and physical risks or alignment of its portfolio to a particular temperature trajectory.

We then provide an overview of the NGFS scenarios, which are used as a common underpinning to a series of case studies evaluating transition and physical risks in Sections 4 and 5. Section 6 includes case studies on use of scenario analysis with respect to alignment of portfolios to a particular temperature trajectory and how utilising scenario analysis can aid portfolio construction.

## Scenario selection and choice of baseline scenario

As part of establishing a scenario analysis framework, firms should first consider choosing a selection of scenarios covering the following elements:

### A. Baseline scenario (or relevant counterfactual)

A baseline scenario[1] (or relevant counterfactual) is the scenario against which firms will compare the outputs of their scenario analysis. Firms could choose different types of baseline depending upon the purpose of the analysis being performed:

- **Hypothetical pathway that assumes no climate-related risks**: no incremental transition and physical risks beyond those already observed to-date. For example, the economic impacts in the NGFS Scenarios are defined against a "climate agnostic" baseline with no additional transition policies and no physical risk included.
- **Probability-weighted central scenario**: represents the firm's view of the most likely scenario at the time of preparing the forecast. Firms may also have internal views on what is "priced in" by markets and can choose to express this in their baseline[2].
- **Current or pledged policies**: the level of global temperature warming implied by a country's current policies or policy commitments pledged as Nationally Determined Contributions (NDCs) under the Paris Agreement.

This baseline scenario can either be combined with a static balance sheet assumption (i.e. assume there are no changes to the current balance sheet in the future) or a dynamic balance sheet assumption (i.e. incorporate anticipated future changes in the balance sheet, for example to reflect transition plans). See GARP survey results in Section 2 for additional options.

[1] A baseline scenario is different to a baseline period. A baseline period is the period relative to which anomalies are computed. For further details see AR5_SYR_FINAL_Annexes.pdf (ipcc.ch).
[2] One of the aims of scenario analysis is to shed more light on what possible futures could look like, and this in turn will inform financial markets.

## B. Strategic scenario

This scenario should reflect a firm's strategic ambition i.e. the scenario to which a firm wants to align its portfolio. For example, a firm who is committed to facilitating a low-carbon transition can choose to align its portfolio to Net Zero by 2050 (consistent with 1.5°C global temperature warming) or Net Zero by 2070 (consistent with 2°C)[3]. A firm could consider defaulting to a baseline scenario (assuming it is not hypothetical) if they have not yet or do not intend to define an alignment/transition strategy.

## C. Tail scenarios

Firms should also consider at least two tail scenarios that are plausible but more severe and less likely than the baseline. These scenarios could be:

(i) higher transition risk (e.g. disorderly policy action leading to 1.5°C or <2°C temperature warming), and

(ii) higher physical risk (e.g. unabated carbon emissions leading to >4°C temperature warming).

These two scenarios can act as "book ends" while the actual future scenario is likely to fall somewhere in the middle. A more advanced scenario framework may include a range of scenarios between these two with differing levels of severity and a different probability of occurrence. With respect to physical risk, it is important to note that scenarios often don't take account of the potential non-linear impact of tipping points.

## D. Comparing the scenarios

A firm can test its resiliency by comparing risk metrics under tail scenarios to risk metrics under the baseline scenario. However, firms should be aware of the impact of their assumptions on the results. For example, if firms believe the baseline scenario has high physical risk, then the relative impact of a high physical risk scenario will appear relatively smaller than the impact of a high transition risk scenario.

Ultimately each firm can decide which scenarios to include in their framework. To be comprehensive, scenarios should ideally cover both transition and physical risks, although firms may prefer to analyse these in isolation. Regardless of which scenarios are chosen, firms should note that there is a high-level of uncertainty in any forward-looking scenario analysis. Firms should be mindful of this in decision-making and transparent in disclosures and reporting.

# Overview of the NGFS scenarios

Climate scenarios are developed by several institutions, including the IEA, Bloomberg, IPCC, etc[4]. We do not provide an evaluation of these scenarios here, although we do reference some to the extent they are relevant for a specific use case. Firms should consider exploring a variety of scenarios and developing their own views on those that are most applicable to their analysis (see GARP analysis, Figure 5 in Section 2).

**In this chapter, we choose to illustrate how to apply scenarios with case studies using climate scenarios developed by the NGFS. These scenarios were developed to provide a common starting point for the financial sector to assess climate-related risks. The scenarios were primarily developed for central banks and supervisors. They also provide a useful reference point for other financial**

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[3] Note there are many different 1.5°C and 2°C pathways (e.g. delayed action versus early action) which each have different implications in terms of transition and physical risks.

[4] The scope and purpose of these scenarios vary widely and are heterogeneous in nature.

**institutions, including banks, asset managers and insurers, when evaluating the impacts of climate-related risk to their business. They were last updated and expanded in June 2021. There are six NGFS Phase 2 climate-related risk scenarios, which can be differentiated by three categories relating to short-term or long-term policies and technology availability as described in *Table 1* and illustrated in**

*Figure 15*[5].

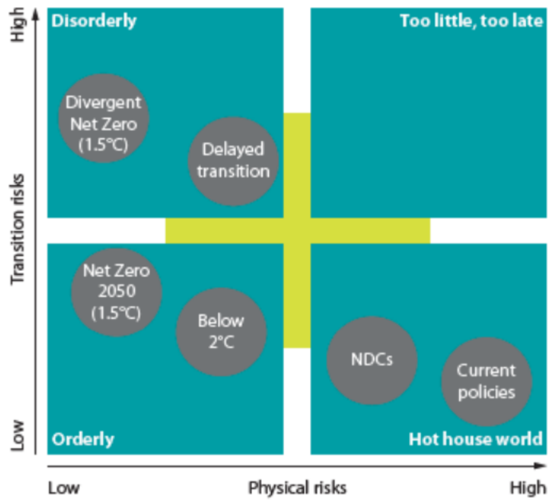
***Table 1: Summary of NGFS Scenarios***

| NGFS scenarios matrix | | High-level narrative | Long-term climate policy<br>Temperature target | Possible mapping in climate scenario framework | Use Case |
|---|---|---|---|---|---|
| **Disorderly** | Divergent Net Zero | Disorderly scenarios explore higher transition risk due to policies being delayed or divergent across countries and sectors. For example, carbon prices would have to increase abruptly after a period of delay. | Limited to < 1.5°C in 2100 | Tail scenario - higher transition risk | Evaluating transition risk |
| | Delayed transition | | Limited to < 2°C in 2100 | | |
| **Hot House World** | Nationally Determined Contributions | Hot House World scenarios assume that some climate policies are implemented in some jurisdictions, but efforts are insufficient to halt significant global warming. The scenarios result in severe physical risk including irreversible impacts like sea-level rise. | Currently (to Dec. 2020) pledged unconditional NDCs are implemented fully, and respective targets on energy and emissions in 2025 and 2030 are reached in all countries | Tail scenario - higher[6] physical risk | Evaluating physical risk |
| | Current policies | | Existing climate policies remain in place, but there is no strengthening of ambition level of these policies | | |
| **Orderly** | Net Zero 2050 | Orderly scenarios assume climate policies are introduced early and become gradually more stringent. Both physical and transition risks are relatively subdued. | Limited to < 1.5°C in 2100 | Strategic scenario | Portfolio alignment |
| | Below 2°C | | < 2°C throughout 21st century | | |

[5] NGFS, Climate Scenarios Database – Technical Documentation V2.2, June 2021, p.4

[6] n.b. while the physical risk is high in terms of temperature, the scenario does not capture the full range of potential effects and impacts associated with these higher temperatures, for example, more extreme weather events, food insecurity, migration and displacement of people.

***Figure 15: NGFS scenarios Framework***




*Positioning of scenarios is approximate, based on an assessment of physical and transition risks out to 2100.*

In

Figure *1*5, the NGFS scenarios are indicated with bubbles and positioned according to their transition and physical risks. These scenarios are set against the backdrop of "Middle-of-the-road" socioeconomic development, where "the world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns"[7]. This backdrop is the second of five "shared socioeconomic pathways" (i.e. SSP2) which were developed by the academic community as an input to climate scenario analysis[8].

The NGFS provides the climate scenarios based upon three detailed and well-established Integrated Assessment Models (IAMs) which model the interaction between human activities (e.g. energy use and corresponding emissions) and the environmental processes (e.g. temperature warming) as well as consider the socioeconomic backdrop (i.e. SSP2)[9].

Overall, the NGFS generates 18 possible future pathways when combining the matrix of six climate scenarios with three IAMs. The outputs from the NGFS scenario runs are baseline parameters used as input to a further model, the National Institute Global Econometric Model (NiGEM), to derive corresponding macroeconomic variables such as change in GDP, consumption, investments, interest rates, etc. for numerous regions and countries. These macroeconomic variables are often more familiar to financial institutions and can be used for conducting internal climate-related risk scenario analysis. The NGFS also provides a Climate Impact Explorer, which contains granular physical risk data[10]. Figure 16 describes the key inputs and outputs of this flow.

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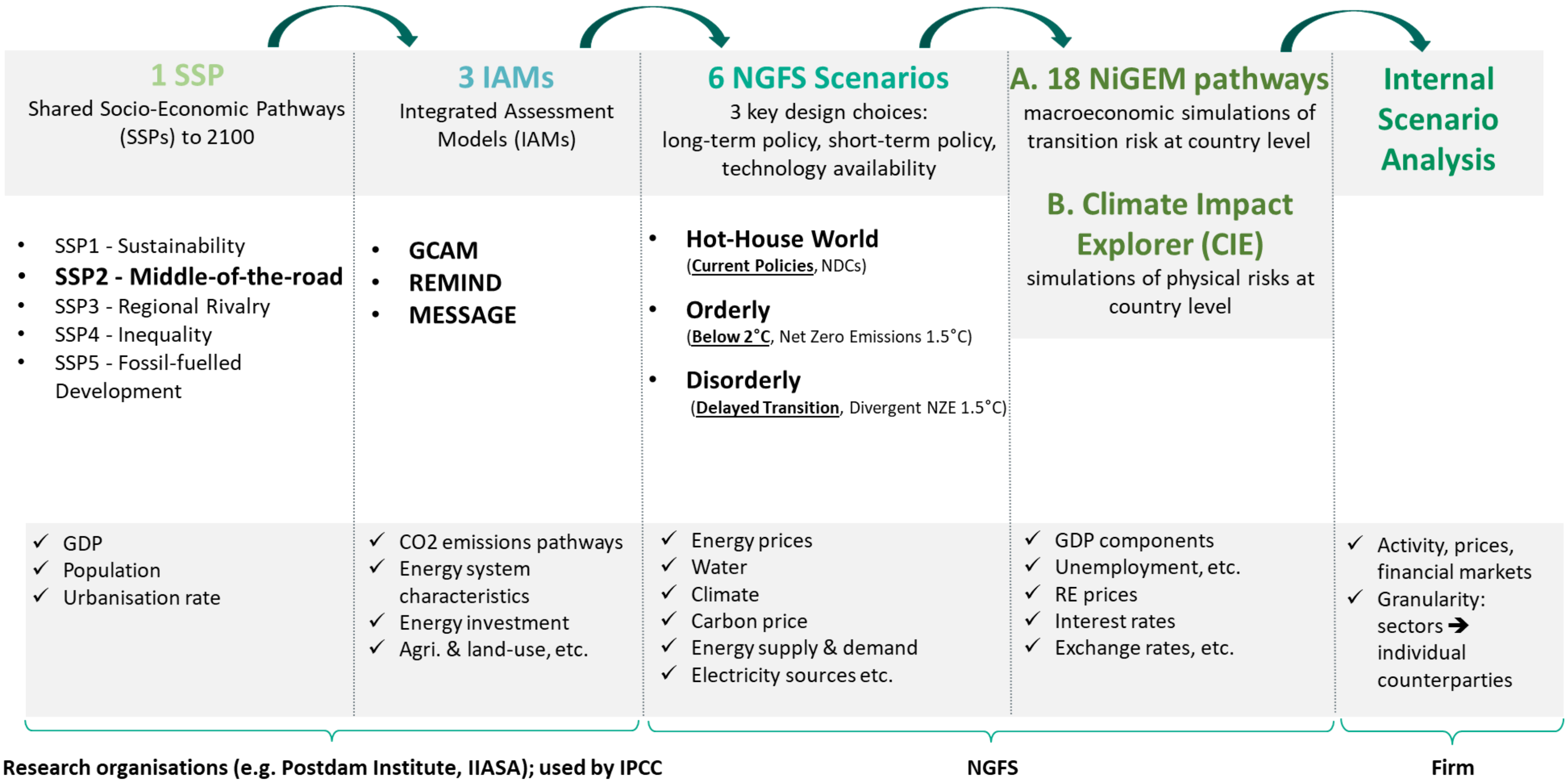
[7] In SSP2, development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain (See CarbonBrief, *Explainer: How 'Shared Socioeconomic Pathways' explore future climate change*', April 2018).

[8] Other SSP's imagine a world taking the "Green Road" (SSP1), a Rocky Road (SSP3), a road divided (SSP4) and one (SSP5) that takes the Highway of the Fossil-fuelled development.

[9] Further detail on the SSPs and IAMs are provided in the 2020 CFRF Scenario Analysis Chapter.

[10] Climate impact explorer

*Figure 16: Climate scenario flow chart (developed by CFRF)*



## Challenges facing the user of scenario analysis

Whichever scenario is being analysed, it is important to ensure that the uncertainties and limitations associated with climate scenario analysis are well understood and clearly communicated when presenting the results in order to ensure they are interpreted and used appropriately[11]. The following summarises some of the key challenges facing the user of scenario analysis.

### Breadth and magnitude of transition and physical risks

Climate change will affect all agents in the economy (households, businesses, governments), across all sectors and geographies. It is hard to know where to start and which effects to prioritise in analysis. The risks will likely be correlated and potentially aggravated by tipping points, in a non-linear fashion. This means the impacts could be much larger, and more widespread and diverse than those of other structural changes.

### Extended and uncertain time horizons and feedback loops

The time horizons over which climate-related financial risks may be realised are uncertain, and their full impact may crystallise beyond most current business planning horizons. Conversely, social tipping points are rarely modelled but may mean some transition elements affect certain sectors abruptly. Using past data may not be a good predictor of future risks and currently there is often little economic incentive to take the short-term actions needed, while there also are some major economic barriers to doing so. For example, over a 30-year period, some companies incorporated into analysis may go out of business and new firms or sub-sectors will come into existence. Technological development adds uncertainty to the speed of low-carbon transition.

### Weakness of many climate economic models

Most scenario analyses are predicated on a degree of market efficiency and thus the smooth rather than disruptive pricing in of transition and physical risks. This extends to the financial sector, where dynamic, non-linear feedback loops between the real economy, corporate earnings, asset prices, asset allocation and financial balance sheets are generally outside of the scope of most models used for scenario analysis.

Corporate impairment estimates under different scenarios also rely heavily on the discount rate used in the analyses. The higher the discount rate applied, the smaller the estimated effect of factors affecting earnings in the more distant future. This is especially relevant when considering the effects of physical risks, where many of the worst effects occur after 2050 under Hot House scenarios, but these years receive very low weights in impairment estimates.

In addition, many economic models of climate impacts perform poorly in higher warming scenarios, with simplistic damage functions that fail to reflect the compounding impacts of a cocktail of physical risks and social implications that are consistent with the science[12]. It is also important to note that the

[11] For example, sensitivity testing could be used to demonstrate uncertainty and the impact of key assumptions.
[12] There are some macroeconomic models available that are tailored for studying the impacts of climate change and recent research has begun to couple these with macro-financial models to assess financial impacts of physical risks. See Risks on global financial stability induced by climate change: the case of flood risks.

current NGFS scenarios do not generally capture acute risks – tail risks from extremes. This is important because these are usually what drives the financial loss. This means that firms need to be careful in how they interpret the NGFS scenarios. In some cases, it might be helpful to start with current risk - including tail risks from cat models and use the NGFS scenarios to help stress those cat models.

Many models assume that the supply structure of the oil and gas market in the future remains like today. The scenario analysis focuses on changes in demand, not supply. Sources of oil and gas available today are assumed to be available to 2050. Removing any of these sources through either policy (e.g. fracking bans) or geopolitics (e.g. conflict or social unrest in the Middle East) could have a material impact on the balance of supply and demand, resulting in higher prices than those expected today and mitigating the transition impacts on producers.

Agriculture, forestry, and land use account for 25% of global greenhouse-gas emissions. But most analyses focus on the energy system incorporating the power, transportation, industrial, and buildings sectors. Transition and physical effects on agriculture, forestry and land use are likely to be significant, though they are less important from an investment perspective because they represent a very small share of the investable universe.

Model shifts in patterns of transportation are also difficult to capture rigorously. This may lead analysts to underestimate the positive effects of the energy transition on low-carbon transport providers.

**Data gaps and comparability of disclosures**

Climate scenario analysis is heavily reliant on high-quality, firm-level emissions-intensity data, including for the different components of a company's activities. While the consistency and quality of greenhouse-gas-emission reporting is improving, neither disclosed emissions nor estimated emissions intensity data is yet available for some companies and for all scopes of emissions. This challenge is also identified and discussed in the CFRF Data & Metrics Report- section 2.

**Cognitive bias**

Cognitive bias must be recognised and accounted for when developing and using any type of scenario. For example, people unconsciously assess probability of a future event or outcome on the basis of how easily they can remember past examples or how easily they can imagine possible events.

**Case study 1: Developing usable climate macroeconomic scenarios**

Any scenario analysis starts with identifying relevant scenarios to be used. This case study describes the experience of developing macroeconomic scenarios at NatWest.

There are a number of climate scenarios from several providers which describe the interplay between climate policy, energy systems and global warming. And while those scenarios provide rich climate and energy pictures, it is also important to understand how shifts in policy and a changing physical environment influence the economy.

The number of climate macro scenarios is steadily building. In time the stock of climate macro scenarios will expand as institutions invest in their own modelling capabilities.

Over the past 12 months NatWest Group has collaborated with the National Institute of Economic and Social Research (NIESR) to develop climate macro scenarios consistent with and to complement the NGFS scenarios. Two components are required for this type of modelling:

- a macroeconomic model, which can capture the key links between climate change and the economy; and
- climate-related shocks, for which their effect on the economy we would like to model.

To perform this analysis, NiGEM – a structural global macroeconomic model developed by NIESR was selected. The key requirements for the model were global coverage with country-specific results for the economies to which the company is most exposed, relative flexibility of possible shocks and policy options, and a solid forecasting track record.

This model was augmented with the ability to consider climate-specific elements. In particular, they were able to explore the following links between climate change and the economy:

**Transition channels** – affecting domestic price levels, economic competitiveness, corporate profits, and government tax revenues via the following variables

- Carbon prices
- Energy demand by fuel
- Energy prices by fuel
- Energy intensity

**Physical channels** – affect level of productive capacity in the economy:

- Damages from acute physical risk.
- Labour and agricultural productivity.

The next step was to calibrate the size of each of the selected shocks for modelled scenarios. The NGFS database was used for all transition shocks, while Vivid Economics estimated the physical shocks associated with the temperature increase predicted by the NGFS scenarios.

Through the exercise considerable insights were garnered, providing the tools for macroeconomic analysis and deeper portfolio level considerations of climate transition. It also provided important grounding for the PRA's 2021 Climate Biennial Exploratory Scenario (CBES) exercise, underpinning the scenario expansion, execution, and portfolio impact analysis stages.

The learnings have been broad based and included the following insights:

1. **An orderly and early transition is strongly preferable to a disorderly one**. Delaying action will cause not only more physical risk to the environment but also damage the economy.

2. **The physical effects are very uncertain**. There are considerable uncertainty bands around the level of global warming associated with a given level of emissions. But on top of that there is no agreement among economists on how global warming will influence the economy. For example, in a scenario where climate policies persist at current level, the impacts on Northern Europe range from slightly positive to significantly negative.

3. **Government policy matters**. For example, what the government decides to do with carbon tax revenues significantly influences economic outcomes. The most beneficial result in our analysis was to funnel those revenues into government investment. This has a short-term positive impact through higher demand and a longer-term positive impact through improved productive capacity.

4. **Investment financing also matters**. It is well known that the transition to Net Zero will require substantial investment. Assumptions about the source of this investment significantly influences assessment of economic results. The most conservative assumption is that there will be no additional investment, but some part of investment flow will be redirected to green projects. The most optimistic assumption is that all transition-related investment will come from new sources and the total flow of investment in the economy will significantly increase. This assumption could change the overall effect on the economy from negative to positive.

5. **Climate affects the economy in a complex way**, and individual impact channels interact with each other. For example, higher carbon prices and the physical effects of climate change may both depress GDP growth. But spending of carbon tax revenues and lower energy intensity both stimulate GDP growth. For that reason, it is not easy to predict the direction of changes due to the combination of multiple shocks.

6. **Global interactions can lead to surprising results**. Even if all countries are negatively affected through one channel, for example higher risk of flooding, but some countries are affected more than others. This could lead to competitive advantage for the less affected countries and result in a positive overall effect.

7. **But perhaps the most important learning is the potential for future insight such exercises present.** Climate influences the economy and wider society in a myriad of ways. Some of the channels are easier to predict than others and can be readily incorporated. But many of the potentially largest societal effects are technically challenging to build into models, because they are very hard to predict. This includes the impact of climate change on local and international conflicts, spread of infectious diseases and migration flows.

These exercises are in their infancy. We are only scratching the surface of the powerful insight these scenarios will deliver as they mature.

# 4. Evaluating climate-related risks for banks

This section considers the extreme climate-related risk impacts represented in the NGFS disorderly, and Hot House World scenarios for banks. It identifies the key data, tools and metrics that can be used and highlights the key features of the selected scenarios as well as guidance on communication of the results of the analysis.

Banks can be motivated to conduct climate scenario analysis for several reasons (see Figure 2, Section 2); including to assess the financial impact of climate-related risks on their company, or to measure alignment to a low-carbon pathway. In this chapter, we describe two applications or "use cases" for NGFS scenarios for banks in turn:

- Case study 3 in this section: Evaluating transition risk in the corporate lending portfolio
- Case study 4 in this section: Evaluating physical risk in the corporate lending portfolio

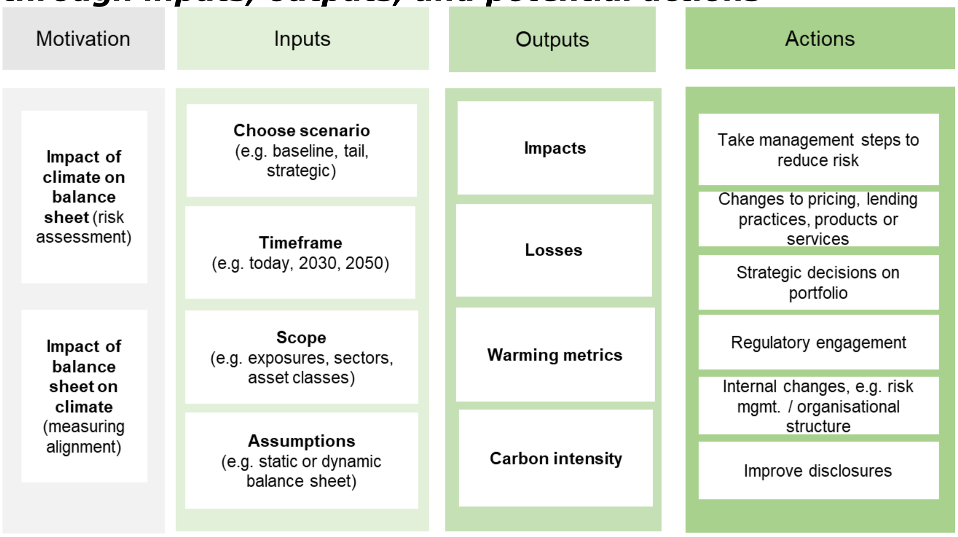
To narrow our focus, we illustrate each use case for the corporate lending portfolio, although similar principles could be transferred to other risk types (such as operational and market risk) or business activities. Retail banks in particular may find it helpful to refer in parallel to the CFRF Risk Management handbook which contains additional case studies and guidance for assessing mortgage portfolios. We also use climate scenarios developed by the NGFS, although scenarios developed by other organisations or "in-house" scenarios could also be used.

We discuss key inputs and outputs for each use case through the following questions and provide a worked case study example for the Oil & Gas sector to make the discussion more tangible:

- What are the key exposures to analyse and why?
- What are the key features or parameters of the selected scenarios for the given use case?
- What are the key metrics/tools to be used to analyse the given use case in the selected scenarios?
- How do the selected scenarios need to be expanded or tailored for the given use case?
- What time horizons should be considered?
- How can the outputs of scenario analysis be effectively communicated internally and externally?

Ultimately banks may want to take management actions on the back of scenario analysis (e.g. changes to lending practices, strategic plans or improving disclosures) although these are not discussed in detail in this section given the variety of potential responses (as illustrated in **Error! Reference source not found.**). We have also provided real world examples in the use cases of how these concepts have been applied in practice by banks to help illustrate the points raised. We discuss key inputs and outputs for each use case through questions and provide worked case studies.

***Figure 17: Example scenario analysis process flow from motivation, through inputs, outputs, and potential actions***



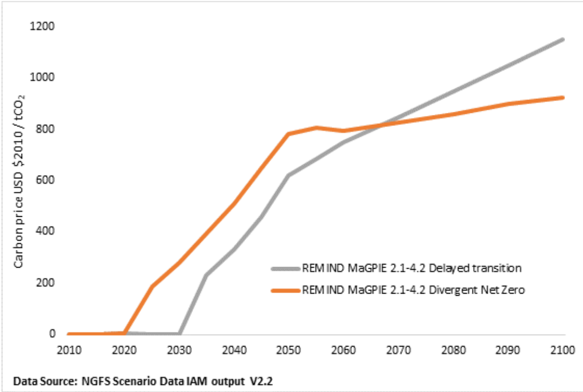

## Evaluating transition risk in the corporate lending portfolio for banks

We focus in this section on how banks can use the NGFS disorderly scenarios - "Delayed Transition" and "Divergent Net Zero 1.5°C" - to evaluate transition risk in the corporate lending portfolio, with an emphasis on the Oil & Gas sector. NGFS scenarios that involve a material increase in the price of carbon emissions can be used to assess transition risk. These two scenarios, in particular, have some of the highest transition risk of the NGFS scenarios; the late policy action is decisive in order to make up ground from the failure to act earlier, which implies a sharper carbon price increase and steeper trajectory after 2030 to meet the same warming targets associated with orderly transition (see Figure 18). This is a source of economic disruption and leads to higher transition risk. Further, there is limited Carbon Dioxide Removal (CDR) technology[13].

**Figure 18: Carbon Price assumptions in NGFS Disorderly Scenarios[14]**

[13] Note that some external reference scenarios rely heavily on the use of Carbon Dioxide Removal (CDR) technologies to achieve emissions targets. However, the feasibility of using these technologies is often debated in the literature. Firms should familiarise themselves with CDR assumptions and understand the implications of these assumptions when using/developing climate scenarios.

[14] This chart displays global carbon prices only, although country-level carbon prices are also available in both Delayed Transition and Divergent Net Zero 1.5°C scenarios (and additionally by sector in Divergent Net Zero 1.5°C scenario).

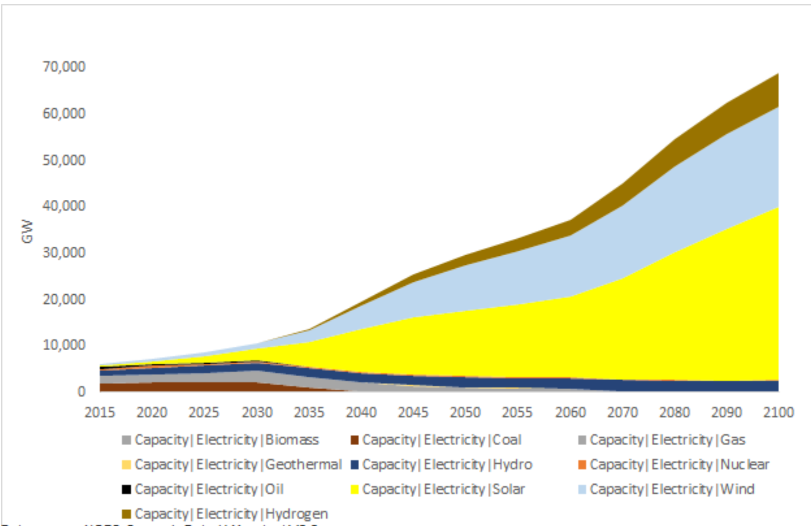



## What are the key exposures to analyse and why?

Sectors or countries with high emissions are arguably most exposed to transition risk in these scenarios, for example, those with broader links to the Oil & Gas sector. These sectors/countries are the most vulnerable to transition pathways driven by either policy change, technology evolution, and shifts in consumer preferences. The Oil & Gas sector is particularly vulnerable in the NGFS disorderly scenarios due to the steep carbon price trajectory and limited use of CDR, which drives a rapid phase-out of fossil fuels in favour of electrified transport and renewable power generation.

Under these scenarios total electricity capacity jumps markedly, but its energy sources change dramatically. In the Divergent Net Zero scenario, solar is the dominant technology representing 48% of electricity generation capacity by 2050, completely displacing coal (before 2030) and gas (between 2030 and 2035). In the Delayed Transition scenario, solar is again the dominant technology but gas progressively disappears from the mix after 2040 (see Figure 19).

***Figure 19: Electricity capacity in the delayed transition scenario (REMIND-MAgPIE 2.1-4.2)***




Data source: NGFS Scenario Data IAM output V2.2

Energy prices are also affected by the transition towards low-carbon alternatives. The NGFS provides parameters for the price of oil, gas, coal, and biomass at three points in the energy value chain.

- **Primary energy prices**: the producers' price
- **Secondary energy prices**: paid by large scale consumers (such as for power production) – this price includes the effect of the carbon price in the scenario
- **Final energy prices**: paid by end consumers (such as residential buildings) – note that electricity prices are also available at this level

Figure 20 illustrates EU oil prices in the disorderly scenarios as an example. Primary energy prices remain depressed throughout the scenario horizon, while secondary energy prices rise in line with the carbon price.

***Figure 20: Oil price evolution in NGFS Disorderly scenarios***

| Disorderly Scenarios | Oil price change compared with 2020 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REMIND-MagPIE IAM | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2070 | 2080 | 2090 | 2100 |
| Delayed Transition | | | | | | | | | | | | |
| Primary Energy | 3% | 25% | -1% | 5% | 12% | 15% | 23% | 46% | 79% | 58% | 4% | 3% |
| Secondary Energy | 2% | 23% | 150% | 195% | 248% | 305% | 315% | 626% | 1013% | 1179% | 1198% | 1299% |
| Final Energy | 9% | 23% | 133% | 174% | 229% | 287% | 295% | 337% | 369% | 382% | 355% | 325% |
| Divergent Net Zero | | | | | | | | | | | | |
| Primary Energy | -6% | 3% | -9% | -8% | -1% | 1% | 1% | -24% | -69% | -54% | -89% | -85% |
| Secondary Energy | 32% | 86% | 95% | 137% | 188% | 240% | 241% | 395% | 559% | 559% | 566% | 570% |
| Final Energy | 26% | 66% | 78% | 114% | 157% | 190% | 183% | 172% | 154% | 144% | 141% | 139% |

Source: NGFS Scenario Data IAM outputs V2.2

These changes in carbon pricing, energy demand/mix and energy prices can result in one or more of the following financial impacts (examples in brackets for the Oil & Gas sector):

- Reduced revenue (e.g. due to decline in fossil fuel demand as consumers switch to low-carbon/electrified alternatives for cars, heating etc; potentially impacting business models)[15]
- Increased costs (e.g. from paying a price on carbon emissions)
- Readjusted capital expenditures (e.g. new investments required to pivot business model towards low-carbon fuels and renewable biofuels)
- Falling asset values (e.g. impairment of the economic value of company assets such as oil & gas reserves and existing infrastructure required for extraction)

**What are the key features or parameters of the selected scenarios for the given use case?**

The combination of changing costs and revenues can alter the financial position for companies impacted by the low-carbon transition, and banks can use the NGFS scenario parameters to evaluate the materiality of this impact. For example, for the Oil & Gas sector specifically (see Case Study for further details):

- Global and regional forecasts of the demand and price of crude oil, natural gas and refined petroleum fuels can be used to calculate the impact on **revenue**
- Forecasts for global carbon price and regional carbon emissions can be used to estimate **increased costs**

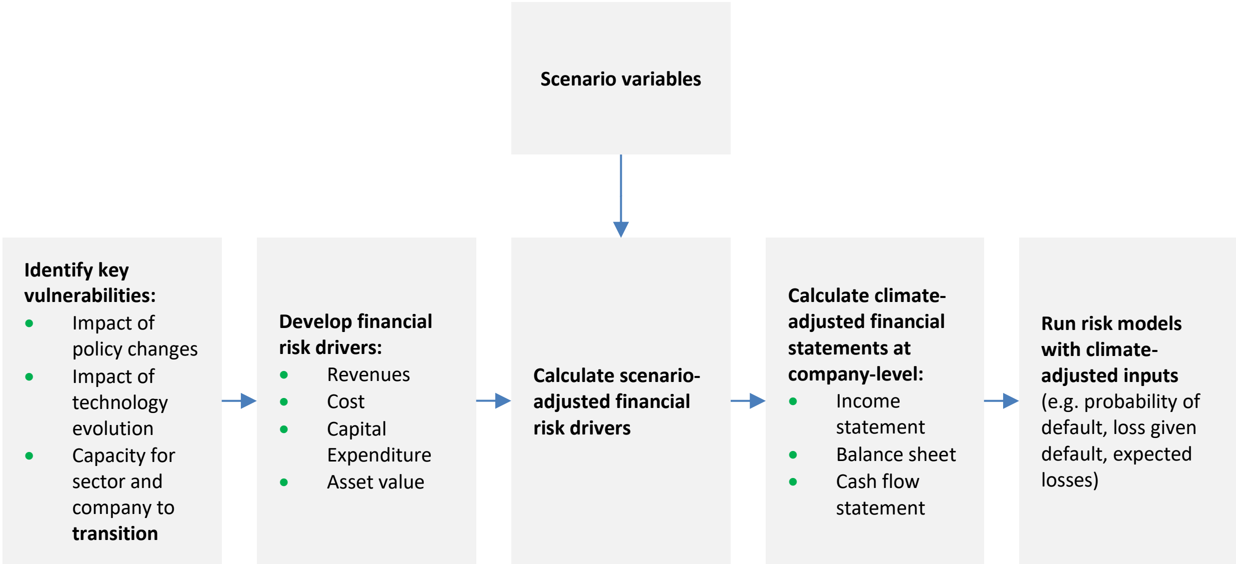
[15] Note that there may be a double effect on revenues since companies may be able to pass on some of the increased carbon costs to consumers in the form of higher prices.

- The NGFS provides capital cost projections for refining plants of gas, oil and biofuels which can be used to estimate the **capital expenditure impact**

## What are the key metrics/tools to be used to analyse the given use case in the selected scenarios?

The impact of the scenario can be evaluated by leveraging on existing internal infrastructure and/or relying on external providers' services. Figure 21 illustrates the key stages involved in running the evaluation.

***Figure 21: Key stages in conducting transition risk assessment for a company***




The following two modelling approaches can be used and may be a helpful complement to one another.

**Company-level assessment**:

This involves adjusting a company's financials using key scenario parameters (e.g. carbon price, energy prices and demand) - see Case Study 3 for an example of how to apply these. These adjusted financials can then be used as input to existing internal models to generate metrics such as climate-adjusted TTC (through-the-cycle) PDs (probability of defaults), LGDs (loss given defaults) and RWAs (Risk Weighted Assets). This approach provides detailed information on the transition impact at counterparty level.

Methodologies may need to account for sector and sub-sector characteristics, such as upstream, midstream, and downstream activities in the Oil & Gas sector. For example, the ability of downstream firms to readjust their business model towards the refinement of biofuels may mitigate the impact of reduced revenue and falling value of their current fixed capital.

Methodologies may also need to account for company-specific characteristics. For example, some Oil & Gas firms may have the ability to adapt to reduced fossil fuel demand, if they have low production costs and high operating margins to start. Further, companies with a credible transition strategy may be more able to cope with a disorderly transition scenario. The credibility of a company's strategy could be assessed using indicators such as: planned R&D investments, its level of carbon emissions, the involvement of their board in transition strategic decisions. The indicators can be calibrated to be either the same across scenarios (i.e. used as parameters) or changed according to the assumptions in the NGFS scenarios, for example, future R&D investments may be less meaningful an indicator in an abrupt low-carbon transition.

**Portfolio-/sector-level assessment**:

The transition pathway can be represented using macroeconomic variables from the NGFS scenarios (e.g. GDP, energy prices), that in turn affect credit risk metrics. The existing models' features need to be adapted to those of the NGFS scenarios (e.g. using a longer time horizon) to explore the full range of impacts.

Note that there are significant known limitations to validating climate-adjusted forecasts and models. These include data insufficiency, lack of historical precedent, relatively underdeveloped and untested models, and material sensitivity to assumptions. Due to these significant limitations, specific attention should be given to benchmarking the model output with external sources of information (in particular from external providers with expertise) and/or developing in-house approaches based on qualitative considerations. Firms can also consider conducting sensitivity analysis to key input variables to understand the impact of assumptions. Comparing to the baseline scenario can give a useful indication of directionality and order of magnitude.

## How do the selected scenarios need to be expanded enhanced or tailored for the given use case?

Leading on from this, to better reflect in-house views and knowledge, banks may want to expand/tailor NGFS scenarios for specific applications including:

**Add further granularity**: expand the scenarios to provide more detailed projections by country, sub-sector, etc to target vulnerabilities of specific portfolios. For instance, using total coal demand to determine thermal coal volumes.

**Consider alternative assumptions,** which may imply:

- Earlier policy action (as the Banque de France has done in their "Variant 2" transition scenario which assumes that abrupt policy action starts in 2025 rather than 2030[16]).
- Further varying carbon price assumptions across countries to explore the impact of policy asymmetry.
- Varying how conservative technological assumptions are. For example,

[16] Scenarios and main assumptions of the ACPR pilot climate exercise.

a lesser role for carbon removal technologies, or slower shift towards electric vehicles.
- Societal changes and consumer preference shifting towards low-carbon alternatives and reducing the need for steep carbon price trajectories.

**Tailor the scenarios to focus on:**

- **A specific geography,** including sub-national granularity, for example decomposing regional variables provided by NGFS into single country variables.
- **Deep dive into specific sectors,** which may require decomposition of energy variables as provided by the NGFS. Transition risk has a significant impact on high emission industries, while for others it is less relevant, for example, the telecommunication sector. Additionally, transition could have positive impact on industries that develop or cater to renewable technologies. To capture the sensitivities of each industry to carbon price scenarios, key sectors indicators can be considered, for example, annual growth in air travel, industry average gasoline usage.
- **Contagion and compounding effects**. Firms could also choose to explore how a low-carbon transition affects less carbon-intensive sectors via contagion (e.g. financial sector, banks, and insurers), or layer transition scenarios onto other tail scenarios (e.g. general macroeconomic downturn) to explore compounded effects – this is relevant since a low-carbon transition will not happen in isolation.

### What time horizons should be considered?

The NGFS scenarios broadly cover the 2005-2060 period in 5-year segments, then reach 2100 in 10-year segments. All NGFS transition scenarios are designed with horizons where the most material impacts arguably occur within the next 30 years to 2050. The key period for the NGFS Divergent and Delayed transition scenarios is 2030-2040 when the economy adapts to the high carbon price regime initiated in 2030. Although this time horizon is longer than the typical maturity of corporate loan portfolios for many banks, it is important to consider these scenarios today for the following reasons:

- Abrupt policy action may occur sooner than 2030; this can be explored by tailoring the scenario assumptions so that the policy action occurs sooner (like Banque de France; see previous section on how scenarios can be expanded and tailored)
- Risk mitigation actions can take time to enact; several banks are starting to release emissions reduction targets often with 2030- or 2050-time horizons (see Portfolio Alignment and Construction section)
- Developing methodologies for assessing transition risk will be an evolving process that will likely take several years.

### How can the outputs of scenario analysis be effectively communicated internally and externally?

The outputs from the transition scenario analysis – such as scenario-adjusted probability of defaults (PDs), LGDs or expected losses – can be compared across scenarios, against a baseline scenario. This comparison gives an indication of the materiality of the impacts of the transition, which can then be compared to current risk thresholds and/or used to calibrate a transition risk appetite (refer to the CFRF Risk Management chapter for more information). However, care should be taken when the outputs of the scenario analysis are communicated for several reasons:

- Climate scenarios are underpinned by multiple assumptions and therefore involve a number of uncertainties (e.g. assumptions about future technology availability and climate policy action)
- Climate scenarios may not fully reflect the range of potential impacts due to compounding effects/tipping points that are not yet captured in the modelling efforts
- The quality of the input data is crucial for meaningful results, although disclosures are continuing to evolve and improve (e.g. indicators on a company's transition strategies may not yet be fully available)
- Transition risk should not be considered in isolation, as there are interdependencies and compounding effects between physical/transition risks, which can be difficult to measure (see Physical risk section)

Banks should consider including the following information to provide context when communicating the outputs of a scenario analysis:

- Presenting results by sector, sub-sectors or activities, locations or countries, current/recent risk profile. This can help identify any key risk concentrations that may require more detailed analysis (for example more tailored scenarios)
- Detailed description of the chosen scenarios and of their assumptions (leveraging providers' own documentation), plus information on any additional expansions/tailoring of the scenario, for example the purpose of the tailoring, data sources used
- Information on the models and tools leveraged, including key limitations of the approach

More information on how to effectively communicate the outputs of scenario analysis can be found in the CFRF Data & Metrics Report - Climate Disclosure Dashboard section.

**Case Study 2: Evaluating climate transition risk for sovereigns**

Sovereigns also face transition risk, and, depending on the degree with which their current economic model will be affected by the transition to a greener economy, or by physical risk from climate change, their creditworthiness might improve or deteriorate with time.

Similar to other counterparties, climate scenarios can be integrated in the ratings process for sovereigns, while continuing to acknowledge limitations/uncertainties in the underlying reference scenarios. Since the climate-related risk horizon is much longer than the usual one of sovereign ratings, stress-testing through the climate change prism can be a challenging exercise. However, this can bring some useful information on their future risk evolution.

The NGFS scenarios provide the evolution of climate and economic variables out to 2100 for large countries and regions. Available data includes, for several regions and countries, the future evolution of GDP in purchasing power parity terms (PPP), population, and the price to emit one tonne of $CO_2$. Investment per energy source and price indexes of primary and final energy commodities are also proposed, together with numerous other data, which can help assess public finance trajectories of oil and gas producers, for example. Agriculture and food data (demand, production, and yields) are also provided, which could help gauge the creditworthiness evolution of sovereigns of whose economies are agri-oriented.

In June 2021, the NGFS coupled its climate scenarios with the NiGEM macroeconomic model, which enables, with more country-level granularity, sovereign ratings simulations. NiGEM provides annual data from 2021 onwards to 2100. Among variables proposed for a long series of countries: GDP, public and private consumption, unemployment rates, policy interest rates, long-term interest rates, imports and exports of goods and services. Many of these data can be used as inputs for internal sovereign rating tools.

While the longer time horizons of 2030, 2050, 2100 etc. may be too long for the rating, the strong hypotheses of political stability, banking system health, current account balance, inflation, and other macroeconomic metrics, can give a good sense of the direction of travel for sovereign ratings.

## Key steps involved in undertaking a transition risk assessment for an Oil & Gas company

The following sets out the key steps involved in undertaking a transition risk assessment for an Oil & Gas company, before applying those steps in a practical case study. Similar principles can also be used to assess companies in other sectors.

| **Step 1** | **Capture company specific data** |
|---|---|

Collect financial data, emissions data, and list of assets by exploring third-party datasets and/or by asking the client directly. Identify the core activities of the company (upstream, midstream, or downstream) and type of company (national oil company, integrated multinational, pure producers, etc.).

The key information that needs to be captured:
(1) Financial Statements
(2) Asset Location & Value
(3) Contribution of assets to company’s overall oil and gas production and/or EBITDA.

| **Step 2** | **Define transition scenario to be explored** |
|---|---|

Select the scenario to explore, for example the NGFS Delayed transition scenario.

| **Step 3** | **Define baseline** |
|---|---|

The baseline scenario may include the effects of transition risk as of today.

The outcome can be defined as a delta over the baseline scenario.

| **Step 4** | **Identify key scenario variables and transitions risks** |
|---|---|

Identify the key scenario variables available in the scenario dataset that are applicable for measuring transition risks for an oil & gas company. This will include variables representing policy action, i.e. the shadow carbon price increases, as well as projections of key sector variables (e.g. regional and/or global oil consumption, wholesale oil price, capital cost of oil extraction & refinery plants).

| **Step 5a** | **Enrich the scenario metrics** | **Step 5b** | **Enrich company data** |
|---|---|---|---|
| Expand or estimate additional scenario parameters, where required. for example, share of carbon price within the price of petroleum fuels, which can be estimated using the carbon price and carbon content of liquid fuel production. | | Enrich company data, where required, for example derive the carbon intensity of specific revenue stream and/or assets, using reported asset-linked carbon emissions and revenue data. | |

| **Step 6** | **Capture the impact of changing costs and revenues on profit/loss** |
|---|---|

Estimate (1) future revenue projections using the scenario paths for fossil fuel prices and domestic or global consumption (as relevant for the company)[17]; and (2) future increased costs using the scenario paths for carbon prices and carbon emissions for specific company activities, accounting for geographical variance (e.g. high-cost vs low-cost countries) where required.

| **Step 7** | **Capture the impact on capex and asset value due to energy transition dynamics** |
|---|---|

Estimate (1) capital expenditure projections based on the change in fossil fuel prices and consumption; and (2) potential impairments in the economic value of fossil fuels reserves (as consumption switches to renewable energy sources before the end of asset lifetime).

| **Step 8** | **Aggregate the different impacts to adjust projected company financials** |
|---|---|

Aggregate the impacts over time of changes in cost, revenues, capex, and asset value on relevant line items of the income statement as well as impacts on cash flow and balance sheet projections.

| **Step 9** | **Estimate the impact of adjusted company financials on internal credit risk assessment/ratings** |
|---|---|

Estimate the changes over time in the overall indicative credit risk rating, including potential change in notches that may lead to adjustment in impairment & provisioning calculations.

## Case Study 3: A transition risk assessment for an Oil & Gas company

[17] The projected scenario consumptions volumes should already demand & supply dynamics in response to increased end-user prices of fossil fuels

Assume the client is a multinational oil and gas company. Its businesses cover the entire oil and gas chain, from crude oil and natural gas exploration, refining and transportation of petroleum products. Its assets are spread over multiple different geographies.

Assume static business strategy, i.e. the company's balance sheet remains oriented towards oil & gas and there is no strategic switch to other businesses activities which may mitigate the impact of transition on the company's long-term financial position. A more advanced analysis may consider how the company's business strategy could evolve to mitigate the impacts of the scenario i.e. dynamic balance sheet assumptions.

| **Step 1** | **Capture company specific data** |
|---|---|

With the support of a third-party data provider if needed, gather company emissions & financial data, including portfolio segmentation (e.g. upstream vs downstream activities). If it is not possible to estimate an individual asset's contribution to the client's emissions and EBITDA, consider making assumptions, for example if the company has oil & gas production in several countries, consider the weighted average of country-specific carbon emission intensities.

| **Step 2** | **Define transition scenario to be explored** |
|---|---|

Consider as example the NGFS Delayed transition scenario which assumes a disruptive transition driven by aggressive policy action (steep increase in carbon price) to decarbonise the economy from 2030 onwards.

| **Step 3** | **Define baseline** |
|---|---|

Consider which baseline to use for comparing the outputs of the scenario analysis. For example, two potential baselines include: (1) Current country policy commitments for decarbonisation and (2) Nationally Determined Contributions as per Paris Agreement. It is also possible to consider the evolving government commitments to Net Zero and/or demonstrated policy actions to reach these commitments.

| **Step 4 & 5** | **Identify key scenario variables and enrich scenarios and company data** |
|---|---|

The increasing carbon price in the NGFS Delayed transition scenario can drive the following impacts for the oil & gas company:

- Disruptive increase in operating costs as its carbon emissions face a rising price in the form a carbon tax or cap & trade clearing price
- Demand for fossil fuel commodities falls sharply as end-user prices surge, which impacts on revenue due to declining volumes of sales in all regional energy markets
- Asset valuation of company reserves will have to be re-priced based on the re-adjusted expectations of much lower demand of fossil fuels in the future
- Capex is also revised in line with expectation of irreversible fall in oil & gas consumption

Below is the list of NGFS variables available which can be used to estimate the size of these impacts. The scenario variables may need to be expanded or enriched, using a combination of expert judgement and available indicators from NGFS, data providers, IEA, OPEC, etc. For example, adding country granularity for variables that have not been downscaled to country-level through the NiGEM model, and if the company operates in select countries only.

Note that a similar analysis can be conducted for companies in other sectors, for example, utility companies that generate power from fossil fuels are also exposed to increasing operational costs (from the carbon price), lower demand for their products, asset devaluation and changes in capital expenditure. Banks should source the appropriate NGFS scenario variables depending on the sector for analysis.

| **Impact drivers** | **NGFS Variable** | **NGFS Mnemonic** |
|---|---|---|
| **Increased Costs** | Carbon price (2010 $/tCO2) | Price\|Carbon |
| **Falling revenue & Asset Value** | Gas price (index) | Price\|Primary Energy\|Gas\|Index |
| | Oil price (index) | Price\|Primary Energy\|Oil\|Index |
| | Biofuel's price (index) | Price\|Secondary Energy\|Biomass\|Index |
| | Refined liquids fuels price (index) | Price\|Secondary Energy\|Liquids\|Oil\|Index |
| | Oil demand (EJ/yr) | Primary Energy\|Oil |
| | Gas demand (EJ/yr) | Primary Energy\|Oil |
| | Biofuel's demand (EJ/yr) | Secondary Energy\|Liquids\|Biomass |
| | Refined liquid fuels demand (EJ/yr) | Secondary Energy\|Liquids\|Oil |
| | Net exports of crude oil (Ej/yr) | Trade\|Primary Energy\|Oil\|Volume |
| **Falling capital Expenditure** | Capital cost of a new biomass to liquids plant with CCS (US$2010/kW) | Capital Cost\|Liquids\|Biomass\|w/o CCS |
| | Capital cost of a new gas to liquids plant with CCS (US$2010/kW) | Capital Cost\|Liquids\|Gas\|w/ CCS |
| | Capital cost of a new gas to liquids plant w/o CCS (US$2010/kW) | Capital Cost\|Liquids\|Gas\|w/o CCS |
| | Capital cost of a new oil refining plant (US$2010/kW) | Capital Cost\|Liquids\|Oil |
| | Investments for extraction and conversion of oil. (billion US$2010/yr) | Investment\|Energy Supply\|Extraction\|Oil |
| | Investments for the production of fossil fuels from oil refineries (billion US$2010/yr) | Investment\|Energy Supply\|Liquids\|Oil |

## Step 6, 7 & 8 Capture the impact of changing costs and revenues

These scenario drivers (leading to falling demand for sold goods, increased cost of sold goods, and asset repricing) can be combined to estimate changes in the income statement and net equity in the balance sheet. The table below illustrates hypothetical impacts on both revenue and costs which ultimately results in a negative profit by 2040. Firms may also want to conduct sensitivity analysis to understand the sensitivity of results to key input variables.

| **Income statement ($M)** | **2019** | **2040** | ***% change*** |
|---|---|---|---|
| Upstream | $14,577 | $12,197 | -16% |
| Midstream | $16,660 | $11,410 | -32% |
| Downstream | $20,825 | $15,738 | -24% |
| Other revenue | $1,076 | $925 | -14% |
| **Total revenue** | **$53,138** | **$40,270** | **-24%** |
| Upstream | $11,543 | $10,985 | -5% |
| Midstream | $13,192 | $12,554 | -5% |
| Downstream | $16,490 | $15,693 | -5% |
| Other costs | $818 | $703 | -14% |
| **Total costs** | **$42,044** | **$39,936** | **-5%** |
| **Gross profit** | **$11,094** | **$334** | **-97%** |
| Depreciation & Amortisation | $1,574 | $1,438 | -9% |
| Impairment | - | $4,782 | *n/a* |
| **EBITDA** | **$5,249** | **$787** | **-85%** |
| **Net profit** | **$1,794** | **-$2,309** | **-229%** |

Key scenario variables driving these results are as follows (NGFS Delayed Transition - Remind-MAgPIE model results).

| **Market drivers** | **2019** | **2035** | ***% change*** |
|---|---|---|---|
| Carbon price ($/tCO2) | 1.9 | 332 | *17374%* |
| Crude oil volume (EJ/yr) | 178 | 157 | *-12%* |
| Natural gas volume (EJ/yr) | 125 | 65 | *-48%* |
| Crude oil market price ($/bbl) | 64.4 | 67.3 | *5%* |
| Natural gas market price ($/mcf) | 2.66 | 4.86 | *83%* |

## Step 9 Estimate the impact of adjusted company financials on internal credit risk assessment/ratings

These "scenario-adjusted" financial statements can be used to determine a "scenario-adjusted" internal credit risk rating of the company. This in turn can be used to estimate changes in the bank's provisioning and risk weighted assets under the chosen scenario.

| **Overall rating** | **2019** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|
| Indicative Rating | A3 | A3 | A3 | Baa1 | Baa3 | Ba1 | Ba1 |
| Change in notches | | 0 | 0 | -1 | -3 | -4 | -4 |

## Evaluating physical risk in the corporate lending portfolio

This section examines the impact of physical risk, with a focus on flood risk, in the NGFS Hot House World scenarios. The following section sets out background and context of the use case, identifies the key metrics that can be used to analyse the given use case and key features of the selected scenarios as well as guidance on communication of the results of the analysis.

Physical risk is generally classified as either acute or chronic depending on the physical effects of climate change, including the impacts on the economy, society, business or financial assets. Increased temperature rise is associated with more (or sometimes less) frequent and severe acute weather events (such as tropical storms, wildfires), as well as chronic changes in the climate (such as rising sea levels and changes in precipitation patterns). The geographical location of these hazards may also evolve as a result of higher temperatures. Physical risk will therefore be more severe in scenarios where future emissions are not limited and/or reduced, thereby leading to higher levels of temperature rise.

We focus in this use case on how to apply the NGFS Hot House World scenarios – "Current policies" and "NDCs" – to evaluate physical risk in corporate lending portfolios, with emphasis on the Oil & Gas sector. These NGFS scenarios assume limited policy action, thereby leading to higher future emissions and significant temperature rise with associated high physical risk impacts:

- **"Current policies" scenario:** Only current policies are implemented, but NDCs are not met. Emissions increase through 2080 leading to significant global warming.
- **"NDCs" scenario:** Governments implement further policies consistent with NDCs; less adverse than "Current policies" in terms of temperature warming and physical impacts.

### What are the key exposures to analyse and why?

Physical risk is inherently location specific, and impacts will therefore depend on the location of a company's fixed assets and/or operations. However, the way in which each company is affected (i.e. the "transmission channel") largely depends on their operating model. This means that applying a sectoral lens can be a helpful starting point. We highlight below some of the key sectors that can be disproportionately affected by the climate change:

- **Agriculture Sector:** Crop production can be hampered due to the impacts of chronic effects such as heat stress, water stress and increased frequency of floods. All of these can affect crop yields and labour productivity.
- **Energy Sector:** Changes in precipitation patterns can affect the river flows and reservoir systems which will have a direct impact on hydro-based power plants. For other kinds of power plants, such as oil, gas, coal and nuclear, the temperature of the water used for the cooling is critical. With increasing heat and drought stress, the production capacity

can be hampered.

- **Airlines and Logistic Companies:** More frequent and severe acute climate events (such as tropical cyclones, storm surges, floods, increased precipitation) can disrupt transport operations and logistics/ supply chains thereby causing revenue losses.
- **Real estate:** Repair costs stemming from acute effects could impact property values and/or crystalize in loans extended to specialised corporates in the real estate sector such as property developers. Over time, this can also drive higher insurance costs. Any other loans secured by real estate property could also be exposed to physical risk.

The sector-specific impacts introduced above can be considered "direct" if they impact cost/damages on a specific asset, or "indirect" if they impact an asset via disruption to supply chains/transport links. In addition, both acute and chronic physical risk can introduce contagion effects (e.g. macroeconomic, or impact on financial sector which are not yet well captured in most external reference scenarios including NGFS. For example, repeated acute events in a certain geography (e.g. heat waves) can lead to decreased productivity because of negative impacts on the workforce (e.g. health, absenteeism). Chronic sea level rise may lead to higher insurance costs and lower disposable income for households at the coast. Banks may choose to start analysing "direct" then "indirect" physical impacts before moving onto "contagion" as data and methodologies are developed.

**What are the key features or parameters of the selected scenarios for the given use case?**

The NGFS scenarios provide information on chronic effects including temperature rise, precipitation levels and crop yields out to 2100, as well as data on surface runoff, snow melt, soil moisture, and biomass density. Phase II NGFS Scenarios additionally provide information on some acute effects such as share of population exposed to wildfires, and annual expected damage from tropical cyclones[18].

Banks will need to choose the appropriate scenario parameters depending on the exposures that they wish to analyse. For example, for an agriculture client, projections of agriculture yield, land cover, heat stress and precipitation are critical. For an oil & gas client, information on heat stress and precipitation are also important, while agriculture yield and land cover are not.

However, banks will also need to ensure that the scenario parameters are available at a meaningful resolution. For example, sea-level rise is an important scenario parameter for a tourism client who owns a hotel along the coastline. But if only the global sea-level rise is available, it is not enough to assess the risk. The sea-level rise in the vicinity of the client's location, as well as the elevation of the property, is also needed. This granularity of data is not readily available in the NGFS scenarios but can be sourced from external data providers as described below. A lower resolution may be sufficient for analysing temperature rise for example.

[18] NGFS Climate Scenarios for central banks and supervisors (June 2020).

## What are the key metrics/tools to analyse the given use case in the selected scenarios?

Scenario parameters can be combined with exposures to produce an assessment of physical risk for a company or portfolio. In particular, the following two modelling approaches can be used, and may help complement each other:

**Bottom-up asset-level assessment** *(see Oil & Gas sector case study)*:

There are several measures which can be used to assess physical risk for individual assets, most of which are common across industry sectors. Ultimately asset-level impacts can be aggregated to company-level to assess the change in financials or probability of default. A more advanced assessment may also consider to what extent adaptation measures (e.g. flood defences) mitigate the impacts. Key measures to consider include:

- **Devaluation of fixed assets:** Corporates may suffer from direct climate impacts such as those arising from acute risks; or indirect climate impacts, which include changes in insurance availability for real estate properties.
- **Increased capital expenditure:** For the sectors which will suffer from chronic impacts of climate change, such as utilities companies (due to shortage of water required for cooling), there will be increased adaptation costs by either building infrastructure for improving resiliency or moving assets to low-risk zones.
- **Business interruption / loss in production days:** Expected assets' downtime due to frequent/extreme events. Based on the locations for production facilities and their exposures to acute climate risk events, metrics should be developed to measure the loss in production, which will eventually affect revenue streams. Impacts to power networks or transport links could also "indirectly" disrupt business activities.
- **Loss of demand:** Climate change will indisputably affect macroeconomic fundamentals across the globe, including purchasing power. Losses in revenue due to adverse impacts on the macroeconomic environment should be also be considered.
- **Sector-Specific factors:** For some sectors, additional metrics which also affect revenue streams can be assessed; for example, reduced output due to the disruption in logistics and supply chains (especially for sectors that rely on components sourced from distant locations or those susceptible to extreme weather). For corporates in the agriculture sector, expected losses in crop yields due to drought, extreme heat/cold, and flooding should be assessed.

**Top-down/portfolio-level assessment:**

Banks can leverage the macroeconomic impacts derived from physical risk from IAMs to conduct portfolio-level assessments. It is worth noting the role that international organisations play here, such as the World Climate Research Programme (WCRP) under the IPCC. These project climate parameters such as precipitation levels and surface temperatures for different scenarios.

Organisations such as the NGFS can then translate these using IAMs to more consumable metrics, which can be used by economists and financial institutions.

Integrated Assessment Models such as the GCAM model, under the framework adopted by Integrated Assessment Modelling Consortium (IAMC), provide macroeconomic impact projections at a global level. Additionally, their coverage is generally limited to key headline macroeconomic parameters. Therefore, a more granular decomposition may be required.

In producing physical risk assessments, banks will need to use additional data/tools such as the following:

- **Asset Level Locations Data:** For a financial institution to be able to assess the physical risk for its clients, it is imperative that locations for client assets are known to it. Such data have not been traditionally collected by the banks. However, specialised vendors collect such data and provide it on a commercial basis. For any clients not covered by third-party vendors, banks need to collect the data from clients directly.
- **Geocoding tools:** For products such as mortgages for retail clients, property locations are usually sourced from the banks themselves. However, to be able to assess the physical risk, banks will need to get exact geo-coordinates for the properties. Several of the external physical risk assessment tools, as described below, require geo-coordinates. Some of those tools also have geocoding capabilities.
- **Physical Risk Tools:** Even though organizations such as the WCRP and IPCC provide a plethora of climate parameter projections; these need to be converted into more practical and intuitive metrics such as the risk of flooding for an asset situated nearby a river. There are several companies, especially from the insurance industry, which utilise their own proprietary models to provide physical risk assessments for a given physical asset. Their assessments are done for specific property geo-coordinates and across several hazards such as sea-level rise and storm surge risk for multiple scenarios and time horizons. Generally, financial institutions outside the insurance sector do not have such modelling capabilities in-house, so a recommendation is to leverage on external partners or service providers who have the capabilities. However, it is essential that external tools and modelling be used with a proper understanding of the hazards, risk drivers and scenarios employed. A useful list of service provider tools can be found in the Principles for Responsible Investment (PRI) website. The CFRF have also published a list of available tools.

### How do the selected scenarios need to be enhanced or tailored for the given use case?

To capture the risk most accurately, banks may want to tailor the Hot House World scenarios from the NGFS based on the following considerations:

- **Increased granularity**: headline impacts from physical risk such as estimated GDP losses, should be assessed at a higher geographical resolution to better capture local impacts. Varying attributes specific to a location, including topography and vegetation, could change the likelihood of occurrence and severity of physical impacts relative to headline estimates.

- **Adjust for local adaptation and resiliency plans**: some communities will be better prepared to confront the impact from chronic or acute physical events. In large part this depends on whether communities have developed robust infrastructure to cope with physical risk. In such locations, it could be useful to adjust scenario parameters to consider existing adaptation infrastructure; or consider plans underway to improve local adaptation and resiliency. Conversely, communities with relatively underdeveloped infrastructure could experience more severe physical risk impacts. Considering local insurance availability is also relevant.
- **Expand impact ranges to account for potential tipping points or contagion**: scenarios could underestimate the impacts of physical risk owing to non-linearities or contagion effects which are not captured in reference scenarios such as NGFS. Some non-linearities are produced by biotic processes, such as methane release from dying flora in collapsing ecosystems and may accelerate climate change. Since not all non-linearities and contagion effects are well understood, banks may choose to consider drawing on more conservative/higher impact assumptions to account for these uncertainties. For example, the average global sea-level rise assumed by the external provider might be different from the level defined in the scenario that a bank wishes to use. Calibration of key physical risk parameters is thus essential.

### What time horizons should be considered?

There is a lag between GHG emissions and associated climate-related impacts of around 20-30 years. This means that climate impacts over the next 20-30 years are already "baked in" because of past emissions, while our actions over the next 20-30 years will define the trajectory after that. Accordingly, the physical impacts in climate scenarios tend to diverge from each other beyond the year 2050[19]. This means that, regardless of which scenario is analysed, the outputs of physical risk scenario analysis are unlikely to be materially different before then. However, it is important to also consider the impact of physical risk over a shorter time horizon for the following reasons:

- Potential earlier market repricing of assets that are vulnerable to the physical effects of climate change. For example, properties located in coastal areas could see prices falling even if sea levels are yet to rise enough to cause flooding.
- Changes in insurance costs. For example, current costs may increase for properties in areas that are susceptible to future flooding.
- To ensure adequate time to mitigate risks if required, such as by pursuing greater portfolio or location diversification. This is particularly relevant since some countries/regions may experience the physical effects of climate change sooner than others.

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[19] See McKinsey (2020); latest scientific analysis can be found in the IPCC 6th Assessment Report (link)

Banks should therefore clarify the objectives of their physical risk assessment upfront, then select the time horizon that is most appropriate (refer to Figure 4, Section 2.2 for results from GARP survey). The time horizon selection and range can also be based on what seems most appropriate to the organization given its portfolio structure and products offering.

**Shorter time horizon (e.g. <3 years/ present day risk):** If the goal is to conduct a stress test to compare against risk appetite, then a sensible starting point is the "direct" and /or "indirect" impacts of more frequent and severe acute risks over the capital planning horizon. Similarly, shorter time horizons should be considered for assessing risk to clients engaged in business activities or who own assets that are highly exposed to acute physical risk. Firms may consider looking at where the portfolio has been impacted by physical events in the recent past and developing scenarios off the back of that.

**Medium time horizon (e.g. 3-10 years):** If the goal is to explore contagion or compounded effects then a medium-term horizon may be appropriate (for example, exploring contagion to the financial sector and changes in insurance costs). It is important to translate those insights into actionable policies and strategic plans.

**Long time horizon (e.g. >10 years):** If the priority is to assess locational strategy or adaptation plans for branches of operations, then a longer horizon should be considered. In such case, the assessment of chronic risks, which are longer term, could be more pertinent for informing strategic decisions. However, as mentioned before, earlier timeframes could be considered if potential non-linearities of global warming are assumed.

### How can the outputs of scenario analysis be effectively communicated internally and externally?

The outputs from the physical risk scenario analysis – such as scenario-adjusted valuations of fixed assets or capital expenditure – can be compared to the same metric under the baseline scenario. This comparison gives an indication of the materiality of the risks in the physical scenario, which can be compared to current risk thresholds and/or used to calibrate a physical risk appetite (see CFRF Risk Management chapter). Banks should consider tailoring internal communication for different departments as follows:

- For corporate portfolios, communication should focus on sector-level insights (i.e. which sectors are disproportionately impacted by physical risk). However, clients within the same sector can be affected very differently depending on the exact location and country of their assets and/or production facilities, so individual client-level analysis should be communicated as well.
- For the retail portfolio, communication should focus on location-level insights i.e. locations where underlying property values are most impacted by physical risk. The communication can also highlight the arising opportunities as well. For example, while sea-level rise can significantly affect bayfront properties, which tend to be more coveted,

the premium for properties further in-land could increase.

- For the bank's own operations, communication should be directed to or include the teams tasked with maintaining business continuity. For example, these teams should be aware of the physical risk that potential locations for new branches or data centres may face. However, care should be taken when the outputs of the scenario analysis are communicated for several reasons as already outlined in transition risk section with additional considerations as follows too:

    - Physical risk analysis may rely more on external data/tools than other use cases. The assumptions and limitations inherent in these data/tools should be well understood and communicated as relevant. For example, resolution of physical risk data, location coverage.

More information on how to effectively communicate the outputs of scenario analysis can be found in the CFRF Data & Metrics Report - Climate Disclosure Dashboard section.

## Key Steps involved in undertaking an asset-level "direct" physical risk assessment

In the following we apply key messages from the discussion above into a practical case study that assesses the "direct" impact of acute and chronic physical events for an Oil & Gas company. The first part sets out the principles and key steps involved – which could be used to assess companies in other sectors – before applying this to the oil and gas sector.

*Note that only "direct" impacts are considered in this section.*

| **Step 1** | **Capture Data** |
| --- | --- |
| Capture list of all assets of the company by exploring third-party datasets and/or by asking the client directly. The key information for each asset that need to be captured: (1) Asset location (2) Asset Value (3) Contribution to company's overall oil and gas production and/or EBITDA. | |

| **Step 2** | **Define list of perils and scenarios along with time frame to be considered** |
| --- | --- |
| This step is to determine the appropriate scenario, list of physical risk hazards as well as the time horizon for which the physical risk assessment should be conducted. This list should depend on the geographical location and sector of the companies' assets e.g. sea-level rise is only relevant for companies with assets on the coast, and heat stress may not be relevant for companies with assets in cooler locations. The list of perils may also be different for current day risk and forward-looking risks. | |

| **Step 3** | **Define Baseline Scenario** |
| --- | --- |
| The baseline scenario may include the effects of climate risk as of today. The outcome can be defined as a delta over the baseline scenario. | |

| **Step 4a** | **Capture current gross** | **Step 4b** | **Capture forward looking** |
| --- | --- | --- | --- |

| physical risk | gross physical risk |
|---|---|
| For each asset, capture the "direct" physical risk as of today using either internal or external catastrophe models. | For each asset, capture the physical risk for the future (e.g. year 2030, 2050 and 2100) under different scenarios such as RCP 8.5 (high physical risk), RCP 6.0 or RCP 4.5. |

**Step 5 Capture the impact of risk**

Based on either third-party or internal methodology, translate the physical risk to asset valuation impact (VI) and operational impact (OI). Valuation impact can include the impact on the fixed asset values for a given asset of the company, as well as the expenditure required to maintain the production optimally. Operational impact can include the impact on the production from a given asset. For example, the production at a given plant location will be halted for a certain number of days on average in a given year. This can be translated into revenue losses. The methodology to determine the impact should take in to account the expected increase in both the probability and intensity of the physical risk. The methodology should also consider the model uncertainties beyond a time horizon.

**Step 6 Risk overlays**

Based on, for example, external data or through conversation with the company, capture the risk mitigation or adaptation plans for the company at an asset level. For example, if the asset can withstand fire stress or have an extensive insurance coverage against fire, the assessed valuation impact due to fire related perils can be reduced.

**Step 7 Aggregate the impact of different perils for each asset location**

This step is to aggregate the physical risk impacts due to different hazards for each asset. Different physical risk impacts might affect different types of assets differently. For example, heat stress might not be relevant for a corporate building which is not associated with any production operations.

**Step 8 Aggregate the impact of physical risk for the company**

Based on each asset's importance, for example, in terms of fixed asset value or by contribution to company's EBITDA, aggregate the impact in a weighted manner at the company level.

**Step 9 Further adjustments and client level financial impact**

Based on the client level VI and OI, the financial impact can be calculated. Firms may choose to conduct additional analysis to understand the sensitivity of the financial impact to changes in input variables. Further, as well as the direct impact of climate-related risk described, there are other "indirect" risk transmission channels which can also cause detrimental financial impact on the client. For example, macro impacts can reduce the demand of the product. Supply chain disruptions (including transportation of material to and from production facilities) can also hamper the revenue stream. These additional risks should also be considered as data and methodologies evolve.

## Case Study 4: Asset-level physical risk assessment for an oil & gas company

*Note that only "direct" impacts are considered in this case study.*

Assume the client is a multinational oil and gas company. Its businesses cover the entire oil and gas chain, from crude oil and natural gas exploration, refining and transportation of petroleum products. Its assets are spread over multiple different geographies.

### Step 1 Capture Data

With the support of a third-party data provider or through client engagement, asset location details can be gathered. If their individual contribution to the client's overall EBITDA and their asset value is not available, consider making assumptions, for example, assets hold equal importance for the client in terms of the contribution to the revenues and are of equal value.

### Step 2 Define list of perils and scenarios along with time frame to be considered

For this case study, consider three standardized forward-looking scenarios which are based on Representative Concentration Pathways (RCPs) scenarios published by IPCC[20]. These scenarios are:

- Business-as-usual (RCP 8.5) – Emissions continue rising at current rates. As likely as not to exceed 4°C.
- Strong mitigation (RCP 4.5) – Emissions stabilise at half of today's levels by 2080. More likely to exceed 2°C.
- Aggressive mitigation (RCP 2.6) – Emissions halved by 2050. Not likely to exceed 2°C.

The list of hazards and/or perils relevant for the analysis based on client's location and sector for current and forward-looking risks are as below:

| Climate hazards | | RCP Scenario | Time horizons |
|---|---|---|---|
| **Acute** | Tropical Cyclone | 2.6, 4.5, 8.5 | 2050, 2100 |
| | River Flood | 2.6, 4.5, 8.5 | 2050, 2100 |
| **Chronic** | Sea-Level Rise | 2.6, 4.5, 8.5 | 2050, 2100 |
| | Heat Stress | 2.6, 4.5, 8.5 | 2050, 2100 |
| | Precipitation Stress | 2.6, 4.5, 8.5 | 2050, 2100 |

[20] Note that the release of the IPCC "The Physical Science Basis" report in August 2021 uses a set of five new illustrative scenarios, that builds on the previous RCP scenarios.

## Step 3 Define Baseline Scenario

Define a baseline scenario, against which to compare impacts for 2050 and 2100, for example with the following assumptions:

- The current-day risks carry zero risk premium and hence the impact on fixed asset valuation remains flat.
- Climate change is ignored.

## Step 4a Capture current gross physical risk

The current-day risks were captured for each of the asset:

| Asset ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Overall Risk | | | | | | | | | | |
| Storm Risk | | | | | | | | | | |
| Flood Risk | | | | | | | | | | |

Scale[21]

Extreme High Medium Low

## Step 4b Capture forward looking gross physical risk

The forward-looking risks were captured for each asset and each scenario:

| Physical Risk | Factor | Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tropical Cyclone | RCP 8.5 | 2050 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | RCP 8.5 | 2100 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| River Flood | RCP 8.5 | 2050 | 0% | 20% | 0% | 20% | 20% | 20% | 20% | 0% | 0% | 0% |
| | RCP 8.5 | 2100 | 0% | 20% | 0% | 20% | 20% | 20% | 20% | 0% | 0% | 0% |
| Sea Level Rise | RCP 8.5 | 2050 | 0% | 100% | 0% | 75% | 0% | 0% | 0% | 0% | 0% | 0% |

[21] Scales used in this case study represent the relative vulnerability of locations to physical risks. Vendors can define this relative vulnerability in different ways (e.g. based on annual average realised losses by location) and firms should familiarise themselves with the methodology used. Firms can then use internal approaches or external methodologies to translate this relative vulnerability into IV and OV impacts.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **RCP 8.5** | **2100** | 0% | 100% | 0% | 100% | 0% | 0% | 0% | 0% | 0% | 0% |
| **Heat Stress** | **RCP 8.5** | **2050** | 32% | 30% | 35% | 50% | 48% | 52% | 50% | 28% | 50% | 62% |
| | **RCP 8.5** | **2100** | 50% | 44% | 52% | 60% | 64% | 66% | 64% | 46% | 64% | 72% |
| **Precipitation Stress** | **RCP 8.5** | **2050** | 33% | 30% | 30% | 53% | 23% | 53% | 27% | 33% | 33% | 53% |
| | **RCP 8.5** | **2100** | 37% | 37% | 37% | 53% | 27% | 57% | 27% | 40% | 37% | 53% |

Scale

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low Risk | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | High Risk |

## Step 5 Aggregate the impact of physical risk for the company

The percentage change in valuation impact (VI) and operations impact (OI) was determined separately for each asset type and physical risk type. See table below for 2050-time horizon as an example.

| Physical Risk | Impact | Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tropical Cyclone** | **VI** | **2050** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | **OI** | **2050** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **River Flood** | **VI** | **2050** | 0% | 1% | 0% | 1% | 1% | 1% | 1% | 0% | 0% | 0% |
| | **OI** | **2050** | 0% | 4% | 0% | 4% | 4% | 4% | 4% | 0% | 0% | 0% |
| **Sea Level Rise** | **VI** | **2050** | 0% | 5% | 0% | 4% | 0% | 0% | 0% | 0% | 0% | 0% |
| | **OI** | **2050** | 0% | 5% | 0% | 5% | 0% | 0% | 0% | 0% | 0% | 0% |
| **Heat Stress** | **VI** | **2050** | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| | **OI** | **2050** | 3% | 2% | 3% | 3% | 3% | 3% | 3% | 2% | 3% | 4% |
| **Precipitation Stress** | **VI** | **2050** | 0% | 0% | 0% | 1% | 0% | 1% | 0% | 0% | 0% | 1% |
| | **OI** | **2050** | 7% | 7% | 7% | 11% | 5% | 11% | 5% | 8% | 7% | 11% |

## Step 6 Risk overlays

Next step is to incorporate building adaptation plans for assets and reduce the VI and OI of the asset as relevant, for example asset 4.

| Physical Risk | Impact | Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tropical Cyclone** | **VI** | **2050** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | **OI** | **2050** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **River Flood** | **VI** | **2050** | 0% | 1% | 0% | 0% | 1% | 1% | 1% | 0% | 0% | 0% |
| | **OI** | **2050** | 0% | 4% | 0% | 1% | 4% | 4% | 4% | 0% | 0% | 0% |
| **Sea Level Rise** | **VI** | **2050** | 0% | 5% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | **OI** | **2050** | 0% | 5% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | 0% |
| **Heat Stress** | **VI** | **2050** | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| | **OI** | **2050** | 3% | 2% | 3% | 3% | 3% | 3% | 3% | 2% | 3% | 4% |
| **Precipitation Stress** | **VI** | **2050** | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% | 0% | 1% |
| | **OI** | **2050** | 7% | 7% | 7% | 5% | 5% | 11% | 5% | 8% | 7% | 11% |

**Step 7 Aggregate the impact of different perils for each asset location**

The VI and OI impacts were aggregated by taking a sum across all the assets.

| Impact | Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **VI** | 2050 | 1% | 7% | 1% | 6% | 2% | 3% | 2% | 1% | 1% | 2% |
| **OI** | 2050 | 10% | 19% | 10% | 23% | 13% | 19% | 13% | 10% | 11% | 14% |

**Step 8 Aggregate the impact of physical risk for the company**

Based on the assumption that all assets equally contribute to the company's portfolio, the VI and OI impacts were averaged across all the assets. The overall valuation impact and operations impact are determined to be 3% and 14% respectively.

## Options for combining transition and physical scenario analysis

Although it can be helpful to develop methods for conducting transition and physical scenario analysis separately, given they require different data inputs and tools, it is important to recognise that transition and physical risks are interdependent. Even a highly ambitious transition pathway will also come together with some level of physical risk impacts, and vice versa.

- Banks can therefore consider the following options for combining transition and physical risk scenario analysis: Adjust the severity of the input scenario variables and then combine the outputs. Namely, apply more severe transition scenario variables and less severe physical scenario variables; then combine the outputs of both analyses (and vice versa).
- Keep the severity of input variables constant but change the weights for transition and physical impacts. For example, if the aim is to assess a higher transition risk scenario, keep input shocks for both transition and physical risk unchanged but apply weights such that the output of the transition analysis is more heavily weighted than the output of the physical analysis.

Firms should be mindful of any assumptions made about the "baseline" and how this impacts the ability to combine the results from physical and transition scenario analysis (see section 3 "Climate scenario analysis key considerations").

# 5. Evaluating climate-related risks for insurance and asset managers

This section explores how asset managers or insurance companies can use the NGFS scenarios to help inform strategic decision making for two use cases, namely transition and physical risks. The use cases are described in turn, with detail on the approach and key data and metrics that can be used for analysis, relevant features of the NGFS and/or alternate scenarios as well as guidance on how best to communicate the results of the analysis. We have provided real world examples in the use cases of how these concepts have been applied in practice to help illustrate the points raised.

## Assessing transition risk for insurance and asset managers

This section sets out background and context of the transition use case, identifies the key metrics that can be used to analyse it and key features of the selected scenarios as well as guidance on communication of the results of the analysis.

Transition risks may impact the risk and return potential of asset managers' and insurers' investments. The pricing of the securities held in their portfolio may vary according to the pace and significance of the disruptions prompted by the energy transition, for example if certain corporate holdings are subject to tighter carbon regulation or changes in the demand for carbon intensive products that negatively affect their financials and in turn lead to reduced equity and bond prices. Asset managers' fiduciary duty implies incorporating relevant climate-related risk analysis into the investment process as these factors may result in material financial risks. There are various factors that could determine the significance of transition risk to an asset manager and its clients, for example its asset class and geographical focus or specific investment objectives. We have assessed transition risk through two separate use cases, considering which investments to hold and which insurance business to write.

### *A. Which Investments to Hold*

Transition risk scenarios help identify which securities are likely to be the most affected by an accelerated and abrupt energy transition, for example via a reduction in the value of their assets, and therefore may not be priced appropriately. This in turn leads to consideration of the underlying investment risks and opportunities and may affect investment decisions from two main perspectives:

**Areas for increased investment**

- Issuers focused on climate solutions, for example, renewable energy, green hydrogen, battery electric vehicles, carbon capture and storage (technologies and market set to grow in a Net Zero scenario).
- Issuers with ambitious commitments to reduce their carbon emissions across the value chain in line with the Paris Agreement (leaders of the transition, including issuers from high carbon sectors that are showing leading practices consistent with the Paris Agreement goals).

**Areas for reduced investment**

- Issuers focused on fossil fuels and carbon intensive activities (e.g. Transport, Buildings Materials, Industrials) with no - or a lack of - ambition to change (current and future carbon emissions misaligned with the Paris Agreement).
- Issuers the most vulnerable to transition risks given their geographical and business mix (including jurisdictions most exposed to carbon policy risks and technologies the most pressured by the transition, for example, Internal Combustion Engines in the Automobile sector).

### *B. Which Lines of Business to Write*

The transition risk scenarios can also inform us on which industries or sectors are likely to be affected by an accelerated and abrupt transition. This can help inform how resilient our existing insurance product suites will be in these conditions and whether material changes are required:

- Should we aim to write more in lines and regions with positive climate transition exposure. Should we be pricing differently for this?
- Conversely, should we write less in lines and regions with negative transition climate exposure? When should we aim to transition out of these products and do we actively seek to engage the affected companies to influence plans before hand? How do we ensure customer outcomes are not compromised?
- Can we develop products which serve the business community as we transition to a low-carbon economy (incentives/climate change mitigation solutions, for example, green buildings, renewable energy, motor insurance (pay as you drive / limited mileage policies / reduced premiums for low emission vehicles) or special policies / premiums for green SMEs)?
- Can we develop products which indemnify against climate litigation? Or against possible reputational impacts? We note however that climate liability risk concerns both transition and physical risks.
- Can we work across the industry to develop insurance solutions for properties that would otherwise be deemed uninsurable due to climate change, rather than just "walking away" from such risks? (e.g. Flood Re)

## What are the key metrics/tools to be used to analyse the given use case in the selected scenarios?

### *A. Which investments to hold*

Metrics can be classified into two broad categories:

**Top down: Climate transition-related metrics at global and local level.**

Examples include:

- Carbon price and standard (specific levels).
- Energy mix (breakdown between the different energy sources).
- Carbon emission pathway and goal (temperature rise objective or Net Zero within a certain timeframe).

**Bottom up: Climate transition-related metrics by firm, notably based on TCFD indicators [22].**

Examples include:

- Carbon emissions across the whole value chain.
- Technology and geographical exposure, for example, revenues and earnings breakdown.
- Climate strategy and readiness, for example, Net Zero goals and detailed plans (including interim goals and the implication for financial metrics such as revenues, capex, R&D and margins).
- Climate Value at Risk based on scenario analysis assuming an orderly and disorderly transition providing a quantification of the potential financial impact.
- Climate transition risk ranking by sector and company, which may involve a scoring methodology to map issuers across the spectrum depending on their absolute or relative exposure to transition risk.

### *B. Which Lines of Business to Write*

In addition to the above, the UNEP FI report, 'Insuring the climate transition'[23], suggests two further output metrics based on the impact of climate scenarios:

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

## What are the key features or parameters of the selected scenarios for the given use case?

In order to identify the potential exposure of an investment portfolio, it is beneficial to consider which assumptions could exacerbate transition risk and thus lead to more severe impacts. This helps to spot outliers (issuers most vulnerable to these risks).

Factors that exacerbate transition risks include, for example, 1.5°C-alignment (most ambitious scenario), delayed and disorderly action, and limited level of $CO_2$ removal (CDR) technology deployment. It is worth reiterating that the exposure of an issuer to transition risks may differ from its alignment with certain scenarios due to various factors (for example a renewable equipment manufacturer that has a low carbon intensity may be aligned with the 1.5°C scenario as measured by its lifecycle carbon emissions but still exposed to risks associated with the energy transition if market dynamics (e.g.

[22] The final report of the Recommendations of the Task Force on Climate-related Financial Disclosures notably references 'Scope 1 and Scope 2 GHG emissions and, if appropriate, Scope 3 GHG emissions and the related risks' and 'key climate-related targets such as those related to GHG emissions, water usage, energy usage, etc., in line with anticipated regulatory requirements or market constraints or other goals. Other goals may include efficiency or financial goals, financial loss tolerances, avoided GHG emissions through the entire product life cycle, or net revenue goals for products and services designed for a lower-carbon economy'.
The annex includes the weighted average carbon intensity metric and illustrative examples per sector.
The 'Proposed Guidance on Climate-related Metrics, Targets, and Transition Plans' mentions for example disclosing the impact of climate-related risks 'on financial planning in the following areas: Operating costs and revenues; Capital expenditures and capital allocation; Acquisitions or divestments; Access to capital.'; Carbon price(s) (external and shadow/internal); Proportion of assets and/ or operating, investing, or financing activities materially exposed to physical risks, based on key categories of commonly accepted risks; Proportion of assets and/ or operating, investing, or financing activities materially exposed to transition risks, based on key categories of commonly accepted risks; Amount of expenditure or capital investment deployed toward climate risks and opportunities; Impact of any material climate-related risks or opportunities on financial performance (e.g., cost, profitability, operating cash flow, impairment).
[23] PSI TCFD final report

competition and prices for its products) adversely affect its revenue and margins).

The new International Energy Agency (IEA)'s Net-Zero Emissions Scenario provides a wealth of data that can help translate the 1.5°C temperature rise objective into a multi-decade impact on macro variables (e.g. carbon pricing, investments need) as well as the energy sector in particular and key end use sectors (e.g. Auto, Steel).

Similarly, the PRI's Inevitable Policy Response provides relevant details on the potential implications with a focus on delayed action (e.g. macro, sector, regions) that could unfold within this decade.

Among the NGFS scenarios, the immediate 1.5°C pathways with limited level of $CO_2$ removal (CDR) technology deployment (disorderly) provides an extreme outcome from a transition risk perspective. Among scenarios included in the phase 2 of the NGFS, the orderly Net Zero 2050 and divergent Net Zero reflect the highest policy ambition aligned with the 1.5°C objective.

## Case Study 5: Practical use case of application at a firm

This case study sets out the approach an investment manager has taken to investigate the impact of climate change on specific asset classes and macro variables. This has included a literature review and a review of their own model for certain metrics. This example is linked to PIMCO's climate risk and TCFD disclosure. The context and additional details are available in their annual ESG Report.

### Step 1 Selection of the scenarios

In the context of the integration of climate factors into their internal repricing tool used for scenarios and stress testing portfolios, they initially quantified the possible impact on accounts and benchmarks' portfolio returns of three NGFS scenarios from Phase I:[24] 1) Orderly transition (early, ambitious and gradual action; moderate transition risk), 2) Disorderly transition (late, disruptive, sudden action; high transition risk); 3) Hot House World (limited climate mitigation or action with current policies; high physical risk).

### Step 2 Development of the model

This involved creating a macro model that built on the NGFS scenarios and other sources and focused on the impact on equities and interest rates for individual countries, in part based on carbon prices for transition risk and the impact of physical risk on GDP. Given the uncertainties linked to climate models and data, this work inherently includes a host of assumptions and is exploratory and iterative. Examples of challenges faced include:

- The adaptation of long horizon and multi-year shocks to ex ante risk management systems that are primarily designed for instantaneous shocks.
- The need to balance simplicity with complexity as certain models are more effective with a limited number of variables for which the confidence level and robustness of the data are higher. The addition of

[24] The NGFS published an updated set of Phase II scenarios in June 2021 which superseded the Phase I scenarios.

input factor shocks may cause co-linearity issues and occasionally less intuitive output shocks (for example if assumptions are being made for many variables such as rates for different countries and both bonds and equity prices for certain benchmark and individual corporate sectors).

- There is a lack of empirical evidence concerning the impact on certain macro variables such as inflation.
- Regarding extreme transition scenarios specifically, the focus on carbon pricing is a fruitful approach but needs to be complemented to capture the broader range of disruptions associated with the transition from high to low-carbon technologies and business models.
- Transition risk-related data are especially scarce for certain important fixed income asset classes, notably mortgage-backed securities and municipalities.
- The combination of both transition and physical risks into one scenario poses a challenge as many scenarios model transition and physical risks separately.

### Step 3 Analysis of the results and complementary research

The results suggest different possible degrees of exposure to transition and physical risks, respectively, as a starting point for an account or benchmark before drilling down into the holdings. The next steps involve evaluating sectoral and regional implications (e.g. the potential impact of US Federal policy under Biden over the cyclical and secular horizons or EU's tightening climate regulation) and issuers' climate transition risk exposure and readiness based on various idiosyncratic characteristics (e.g. current and future business mix and geographical exposure, adaptive capacity). It also leads to exploring the specific features of major fixed income securities.

For example:

- **Sovereign bonds**: Potential credit downgrades via the sovereign fundamental spread framework.
- **Corporate bonds:** Potential equity price shock based on a capital structure model.

Ultimately, these analytical frameworks serve the whole spectrum of the company's ESG-specific and broader investment strategies and enable the company's ESG dedicated strategies to align with the TCFD recommendations.

### Step 4 Connection to the use case

Specific uses cases include:

#### 1) Evaluation

The firm's global credit research team and portfolio managers aim to evaluate climate-related issues across the issuers that they cover as part of their analysis. At portfolio level, scenario analysis serves to support the monitoring of funds' climate-related risk exposure by the firm's Portfolio Management team. The negative impact of extreme transition risk scenarios appears to be greater for carbon intensive portfolios relative to low-carbon funds, as expected. At bottom-up level, the most aggressive energy transition scenarios provide a benchmark as they evaluate companies' exposure and emission reduction targets and strategy. This informs their environmental assessment that is part of their proprietary ESG scoring system. Ultimately, it helped reinforce their conviction regarding climate laggards and leaders, with the latter defined as debt securities of issuers they deem to be at the forefront of the Net Zero transition. Issuers considered to be climate leaders are therefore emphasized in the firms' Climate Bond Strategy.

**2) Engagement**

The firm's engagement aims to help issuers improve their management of the underlying credit risks, moving from awareness to readiness, and ultimately commitment to reduce their carbon emissions relative to pathways consistent with the Paris Agreement. In the context of their dialogue on the implementation of the recommendations of the TCFD, for example with energy companies, they have notably raised the opportunity for issuers to reflect on the impact on their business of more aggressive energy transition risk scenarios than the widely used IEA Sustainable Development Scenarios (SDS), given that those shed light on potential areas of vulnerability that may not be otherwise as apparent. For example, if a more aggressive assumption is made for future energy or carbon prices that help see which projects and businesses would no longer be competitive.

### How do the selected scenarios need to be enhanced or tailored for the given use case?

Section 4 sets out detailed areas to consider tailoring the NGFS scenarios for banks and those are equally applicable for asset managers and insurers. It is important to recognise that no scenario is perfect and although they are a very helpful starting point, there may be elements missing from the off the shelf scenarios. Investing in ensuring the scenario represents the key risks that your portfolio/products are sensitive too is important.

The overarching challenge is to build tools that translate climate models into both top-down macroeconomic inputs and bottom-up inputs. In other words, Net Zero scenario and transition risk variables need to be linked to macroeconomic parameters (e.g. growth and interest rates) and ultimately specific issuers and securities, across relevant asset classes relevant to the portfolio in scope (e.g. both listed equity and fixed income for corporate issuers but also sovereign bonds, municipalities, asset-backed securities).

For example, conversion of the IPCC 1.5°C scenario into a carbon emissions pathway that is relevant at sector and issuer level remains a work in progress among the certain corporate carbon performance benchmarks as they have historically been focused on scenarios closer to 2°C (e.g. Science Based Target Initiative, Transition Pathway Initiative) or had a partial coverage of sectors (e.g. the data and methods to evaluate the financial sector's exposure to extreme transition risk via direct and indirect risks, associated with a Net Zero scenario, including second order effects have been less developed).

The time horizon of the analysis can also be adjusted to reflect the possibility to see these risks materialising sooner than in the NGFS scenarios.

This needs to be further translated into specific assumptions in respect of insurance products and should be considered at an appropriately granular level of the portfolio to ensure meaningful analysis:

- How will this impact pricing?
- What are the implications for lapses and new business rates?
- Are any products/regions/industries no longer viable to insure?
- Are there opportunities to provide alternative products/cover to different segments or industries?

## How can the results of scenario analysis be effectively communicated internally and externally?

There are a range of potential audiences to consider when deciding how to communicate the outputs from the use cases. These include the board and key strategic decision makers internally and externally, such as regulators and investors.

**Internally**: this may be integrated into core stress-testing tools, portfolio risk profiling and research to enable the portfolio management team to systematically monitor and mitigate these risks as appropriate. It is also important to connect the output of these scenarios, which are typically associated with a long-term outlook, with more immediate investment impacts based on regional and sectoral implications. Typical examples of transition risk factors that already have an impact or are likely to have an impact over short and medium-term time horizons include tightening carbon policies, changing economics for high versus low-carbon technologies (e.g. for renewables compared to fossil fuels) or the impact on investment flows associated with the growing awareness of transition risk (e.g. the fossil fuel divestment momentum).

**Externally**: the level of granularity and perspective depend to some extent on the context. For example, whether this is for a specific mandate or ESG-labelled funds or the strategy overall i.e. broad investment portfolios with no specific climate objectives or characteristics. For publicly listed issuers it should ideally be integrated into the core financial disclosures (integrated reporting).

More information on how to effectively communicate the outputs of scenario analysis can be found in the CFRF Data & Metrics Report- Climate Disclosure Dashboard section.

## Data requirements

The areas considered below apply equally across each of the scenarios and where there are particular differences these are specifically identified.

### *A. What are the data requirements?*

Data requirements needed to assess the impact of climate-related risk on investments can be classified into two broad categories:

**Top down**

- Policy actions, timings, intensity, localisation, and impact.
- Macro model including transition metrics and common indicators such as growth, inflation, sovereign bond spreads, indices.

**Bottom-up**

- Climate transition- related metrics by firm (as previously mentioned) and their impact on financials.
- Market and security valuations, including models suited to specific asset classes (e.g. discounted cash flows (DCF) models for listed equity or capital structure models and the treatment of downgrade risk impact for bonds) and risk models.

Overall, it is beneficial to allow flexibility regarding scenario assumptions that drive the results and use a range of scenarios, with the NGFS scenarios being a basis to build on. Indeed, there are large uncertainties regarding the timing, probability and significance of these shocks. For example, stricter carbon policies or tipping points for disruptive low-carbon technologies may occur faster than projected by the main scenarios that serve to uncover transition risk. Ultimately, different scenarios help to evaluate these nuances and increase the understanding and readiness to cope with these risks.

In addition to the above it is important to consider qualitative information on how different lines and regions are likely to be impacted by transition risk:

- **Energy**: more focus on renewables and more pressure on fossil fuels, especially coal.
- **Property**: different construction standards.
- **Personal**: move away from combustion engines to e-cars, changing customer behaviour, for example, less travel, more home working.
- **Transport**: move away from combustion engines to electric powered vehicles (and more broadly to low-carbon transport modes across Auto, Shipping, Aviation, which involve other technologies, for example, biofuels, hydrogen, and environmental risks, for example, tightening air pollutants).
- **Financial lines**: possible increase in D&O claims due to senior management failing to address the risks to their businesses from climate change.

### *B. What are the current approaches to access the data and metrics?*

There is a combination of publicly available data and those accessible via vendors.
Sources include for example:

- NGFS guides and scenario database.
- International organisations (e.g. IEA, IRENA, IMF, World Bank), think tanks (e.g. 2DII, Carbon tracker Initiative), consultants (e.g. Vivid Economics) and data providers, including ESG and climate rating agencies and consultants (e.g. as sources of raw carbon data).
- Academic literature (e.g. Mercure, J.-F. et al[25]).
- Proprietary models and research.

[25] Macroeconomic impact of stranded fossil fuel assets.

The NGFS may be seen as a particularly user-friendly starting point and set of scenarios available off the shelf while other sources are more suited for a deep dive based on a proprietary model.

This can be supplemented by internal discussions with key stakeholders and benchmarking exercises, for example:

- Discussions with underwriters.
- Discussions with claims managers.
- For benchmarking purposes on reporting, database from initiatives for example, CDP which includes a section on insurers.

The above mainly refers to insurance liabilities. Further guidance on considering the impact on assets is set out in the portfolio construction case study in section 6.

Learning from existing sensitivities is really important. For example, how was the portfolio/business less affected by major shocks (of a similar nature) in the past and what can be learnt from this about the future vulnerabilities and risks?

### *C. What tools are available?*

There is a growing number of tools that can shed light on transition risk, including both sources that focus on the carbon risk implications (focus on financial risks) and those that cover principally the carbon performance or alignment perspective (consistency between the carbon emissions of an entity and the global climate goal):

- NGFS Scenario Explorer
- PACTA
- IEA scenarios (Net Zero)
- Climate Action 100+ benchmark
- EU taxonomy for climate change mitigation
- SBTi
- TPI
- World Bank Carbon Pricing Dashboard

NGFS Scenario Explorer, IEA scenarios (Net Zero), and World Bank Carbon Pricing Dashboard may for example help with macro assumptions (e.g. how carbon prices evolve per region and differ per scenario).

At a bottom-up level, PACTA, Climate Action 100+ Net Zero benchmark, SBTi or TPI primarily help evaluate an issuer’s readiness to cope with climate risks and its alignment with certain scenarios.

It is noteworthy that the number of tools and datasets that help evaluate transition risk and are available free of charge has been increasing. The CFRF also published a list of available tools.

### *D. What are the key barriers to overcome, and options to address them?*

There are a number of barriers to overcome including:

- Connection between climate data and existing macro and bottom-up

valuation techniques.
- Data availability and quality, especially for certain segments (e.g. private, High Yield and Emerging Markets for corporate bonds or securitised).
- Lack of external disclosures on potential impacts of transition risk on companies which could inform underwriting decisions.

Enhanced disclosure is key, including via the incorporation of climate factors into mandatory financial reporting and regulation and the standardisation of carbon accounting at issuer and portfolio level (e.g. certain initiatives such as PCAF have focused on the methodologies for financed carbon emissions).

As regards data availability, some reasonable assumptions can be made in certain instances e.g. using the issuer's sector or business mix and producing average or median for carbon emissions based on its peers with data, or the literature on lifecycle emissions per technology and geography. Another approach may involve being focused on business or financial variables directly instead of carbon emissions (e.g. as mentioned previously future energy prices or costs associated with carbon pricing).

## Assessing physical risk for insurance and asset managers

This section considers the extreme physical risk impacts represented in the NGFS scenario. The specific examples illustrated in the following sections focus on flood risk impacts for a general insurer. Flood risk was selected due to materiality: flood and windstorm are the two most material natural perils for UK insured properties, and as the example illustrates, flood risk is subject to greater change than wind. While the examples cited relate to a UK property risk portfolio, the principles could be applied across any geography and for different weather perils.

Flood risk can be 'pluvial', i.e. intense downpours causing flash floods, or 'fluvial' where prolonged rainfall causes saturated ground and rivers to overflow, or 'coastal', i.e. storm surges, which can be exacerbated by sea level rise and subsidence due to aquifer depletion. The example scenario focuses on the fluvial and is set in the context of longer and wetter UK winters occurring more frequently.

The insurance market already devotes much resource to flood modelling and flood mapping, as a key weather peril. When examining extreme climate scenarios for the NGFS, this does not create wholly new use cases, but is more about gradually varying existing tail risk use cases.

Different insurance entities will have different areas of focus, depending on the size, risk profile, business mix etc. Climate change risk assessment should be proportional to the risk and the approach to scenario analysis and quantification should be relevant to the most material risk to the company.

Hence risk identification is a good first step, starting with a high-level view of the firm's main exposures, which weather perils are significant for these and which are changing faster. There could be the following objectives to the exercise:

**Product**

- Product development
- Claims capacity planning
- Risk engineering to improve prevention and resilience (typically commercial property or construction & engineering risks)

**View of risk**

- Pricing
- Underwriting and risk selection

**Risk management and mitigation**

- Aggregate exposure management
- Reinsurance strategy and purchasing
- Capital adequacy/Regulatory compliance

It is also worth considering the macro-environment and the role that stress testing can play in helping influence this environment. Particularly relevant to this use case is the long-term future of Flood Re which was initially established for a 25-year period. It is important that in developing use cases insurers consider how they can be used to help influence public policy engagement on flood defences, building regulations, local/civic planning strategy, infrastructure roadmaps and projects. It is worth noting in this context that it is not just climate scenarios that are important to consider, but also other scenarios that can interact e.g. compound risk scenarios. This includes policy scenarios such as a withdrawal of Flood Re. or other important factors.

EIOPA's opinion[26] on climate change risk scenarios within the ORSA process states that insurers should consider both short- and long-term potential impacts from changing frequency, severity and distribution of physical risk including flood. This requirement includes the need to consider changes in the scale and extent of losses which could occur due to future hydrological and meteorological events such as floods, especially in respect to assumptions regarding risk transfer through reinsurance.

### What are the key metrics to be used to analyse the given use case in the selected scenarios?

The types of metrics used to assess the potential impact of physical risk to insurance undertakings will include those commonly used within the Solvency II process. When using these, a number of characteristics of the data and their suitability for representing current and future trends in physical climate-related risk including extreme flood should be considered:

- **Exposure and claims data** – including both modelled and historical, and key benchmarking data sources as well as historical (e.g. own claims histories) and third party (e.g. commercially provided or open source) data sources, as well as how climate is changing the nature and probability distribution of weather perils.
- **Modelling capabilities/licensing** – evaluation of model provenance, suitability and assumptions / strengths and weaknesses for representing

[26] EIOPA opinion on the supervision of the use of climate change risk scenarios in ORSA.

material risk to the portfolio and balance sheet. It is important to recognise that it is unlikely that any model will be a perfect fit but that the best choice is made given the intended use case and questions to be addressed, and that limitations are well communicated.

- **Geography** – regional, national and international materiality and variations of risk, at a level of granularity that is useful to capture relevant variation in climate and catchment characteristics (e.g. NW England vs SE England).
- **Stakeholder** – who the audience is and what the intended outcomes are.
- **Materiality of the risk and proportionality of the methods selected**
- **Granularity of assessment**
- **Scientific view on current perils** – for example, IPCC current view on trends in regional flood risks under different pathways.

As noted above the insurance market already devotes significant resource to tail risk flood modelling and flood mapping, as a key weather peril and have developed highly sophisticated and detailed models to support this, albeit calibrated with historical data and for present day and near historical flooding patterns. These models are able to assess:

- Flood risk and expected losses by property.
- Aggregate flood exposure by catchment area / river valley / plausible weather event.
- Mitigating impact of flood defences based on given design thresholds.

However, simply relying on historically calibrated flood models means that decisions will be based on data that does not take account of potential future changes in frequency, severity, distribution and adaptation. The uncertainty in how fast and how far weather extremes change is a growing component of model risk, for which there are useful tools such as sensitivity tests around key model parameters. Timeframe is an important consideration. Over a single year, the delta from allowing for climate trends is often immaterial. The impact on a typical UK household policy even under severe climate trend assumptions would currently be negligible. In addition, the modelled scenarios do not represent prudential risks on a one-year basis. However, over 5 to 10 years it can become significant and can influence strategic decision making.

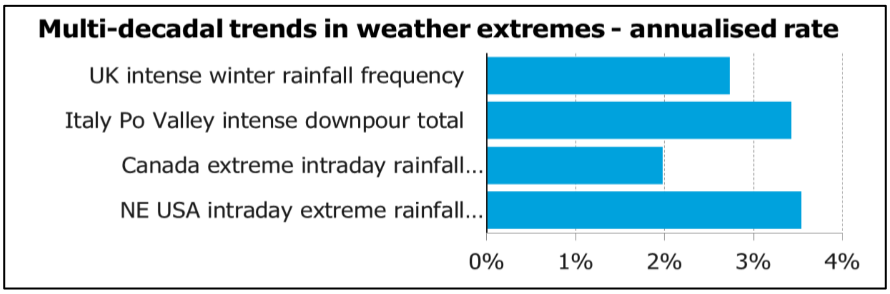
**Case Study 6: Impact on Reinsurance Strategy**

The starting point for scenario selection at RSA[27] arose from analysing the "so what?" question: which aspects of climate change are most relevant to near-term business and risk management decisions. Although the near-term impacts can seem immaterial as many weather averages are changing only very gradually, a more meaningful use for analysis can be focussed on extremes. Insurance perils are driven by the tail of the distribution rather than the mean which can show a greater signal from climate change in the short term. Therefore, the analysis focused on extremes and identified three trends with business implications of particular interest.

[27] The RSA analysis described was performed prior to RSA's takeover, and relates to the former UK-listed group with extensive general insurance operations in UK, Scandinavia and Canada as well as other territories.

More frequent downpours: it was hard to find relevant long-term analysis based on real data of how the distribution of extreme rainfall events had already been affected by global warming over recent decades (although recently there are a growing number of model-based event attribution studies for precipitation), so the firm undertook their own literature search and meta-analysis. This identified several multi-decade studies, some of which overlapped with the firm's geographical footprint. Each study showed an increasing trend in frequency of intense 24-hour rainfall, by a factor of 2-3% per annum.

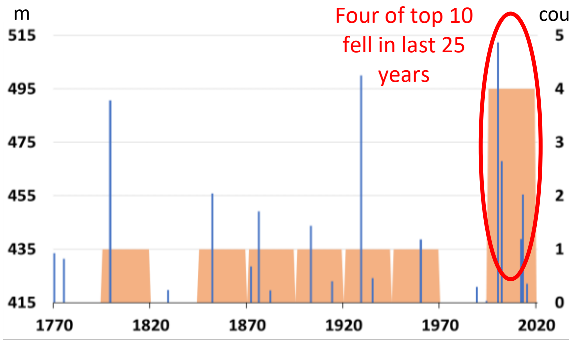
***Figure 22: Multi-decadal trends in weather extremes***




*Source: RSA Analysis*

- The firm quantified the impact on key assumptions and year on year decisions of allowing explicitly for an annualised effect of a long-term background climate trend of this magnitude in flood risks. They recalculated multi-year averages which informed an increase in weather loadings. A simplified approach was used to get a sense of magnitude at a 1-year scale, later complemented by more sophisticated scenario modelling of non-linear effects (e.g. catchment, ground saturation etc).
- They stress tested their reinsurance strategy and pricing by overlaying these trends as an inflationary effect on top of historical flood risk data. This informed design and break-even value of their 2021 reinsurance strategy decisions.
- Correlation in weather systems across different geographies: There is increasing data and research (by the UK Met Office and others) on northern-latitude pressure phenomena including Rossby waves in the Jet Stream, potentially resulting in simultaneous prolonged weather events, for example, strong storms, heavy rainfall and freeze over large areas. This matched the firm's international geographical footprint of Canada and Northern Europe, so it was identified as a potential vulnerability. For this scenario the firm used their internal model to test the sensitivity of the aggregate catastrophe loss distribution and of capital requirements to adjusting copulas to yield more simulations with windstorm, flooding, and winter storm occurring concurrently across these areas.
- Extended periods of rainfall: They were also interested in prolonged rainfall and 'conveyor belts' of rainstorms, as experienced in UK in May-July 2007, 2013 and 2016. England has high quality daily rainfall data for the last 250 years. They analysed the patterns over 1, 2- and 3-month rolling periods, and found the strongest signal was the increasing frequency of 3-month heavy winter rain (and a decrease in the summer months).

***Figure 23: Top 10 in last 250 years for UK 3-month winter rainfall***
*Source: UK Met Office, RSA Analysis*




This last trend of interest (the increased likelihood and severity of long-duration winter weather events) stood out as a potential reinsurance stress. The firm therefore developed a scenario test to examine the potential impact of multiple similar and severe flood events back-to-back. Extended duration can magnify such impacts both through physical effects (ground saturation) and through multiple reinsurance 'events' (as the duration is too long to count as a single catastrophe). The firm built a representative extreme UK winter using daily rainfall patterns from the 2013/14 and 2015/16 UK winters, and used actual granular physical loss data from the 2015/16 winter storm as the base case to model the losses. Their Board's reinsurance strategy decision took the results into account both in terms of the value of key components of the programme and also the relative importance of different features.

The use case can also be used to influence product development and community engagement:

**Case Study 7: Overseas insurance market product development**

Canada has experienced an increased frequency of heavy rainfall, snowpack, ice jams and windstorms resulting in recurring flooding and infrastructure damage. For example, the last decade has seen significant flood events including 2013 Alberta, 2017 Quebec, Spring 2019 Ontario, Quebec and New Brunswick, and Spring 2020 Alberta. In response, RSA has improved household insurance products available to customers offering protection for water-related damage. These now include enhanced Waterproof Coverage (providing protection against damage caused by storm and flood to eaves, downspouts and drains) and Enhanced Limited Sewer Back-Up Endorsement.

To raise awareness of the need to build resilience to extreme weather, the firm undertook a research study with WWF Canada to explore Canadian attitudes to flooding and environmental resilience, highlighting the need for greater education and community collaboration.

- In Canada, nearly one in three people don't know what water damage coverage they have or need, and in Canada not all home insurance policies include cover for flooding. This means that many homeowners have been finding out - too late - that flood is not covered by their home insurance policies. The firm has been supporting the Insurance Bureau of Canada's public policy agenda for the insurance industry around environmental

initiatives such as flooding/extreme weather preparedness and resilience and call for a Canadian National Flood Action Plan.
- Working with WWF Canada the firm has also sought to improve Canadian flood education and to champion nature-based solutions to improve flood resilience. This included bringing community leaders together to discuss flood vulnerability assessments and developing a community flood resilience toolkit piloted in New Brunswick to help municipalities understand the value of and protect publicly owned wetlands, as well as restore land along river banks, and wetlands and forests in watersheds where there is an opportunity to do so.

The use case can help shape the development of future data sources, as outlined in the next case study:

**Case Study 8: Enriching flood risk analytics**

RSA Canada has partnered with OPTA (an external data provider) to enrich data for pricing for weather and escape of water perils. The firm has been assessing new models for flood perils to improve understanding of exposures by provinces and how these translate into pricing changes. This includes reviewing and modifying the current zoning used for property lines for flood losses, as well as assessing the impact of flood defences and changes in regional hydrology on flood ratings. Also, following severe flood events in recent years, the firm evolved flood models to incorporate both surface water and coastal/storm surges.

Over several decades however it can be very material – a number of flood risks double (as shown in case study 6 above). By the end of the 21st century the projected changes in losses could have significant impacts on sustainable business in the worst scenarios. This therefore changes the emphasis towards addressing the system risk to ensure these risks remain insurable in the future including:

- Relative priority of flood defences, and their design thresholds.
- Influencing the Future of Flood Re[28]. This has been one of the most effective pooling systems when comparing internationally and secures insurability for homes (pre-2009). Given the systemic nature of the risks modelled in these scenarios could the outputs be used to influence whether this should be extended to small businesses in any future iterations or revision?
- Influencing public policy. Severe or repeated flood events are likely to affect property prices and costs to property owners as we have recently seen in the UK, for example, with cladding. This could be compounded in locations particularly susceptible to increasing flood risks. This could have wide-reaching broader economic impacts to certain communities and regions.
- Systemic mispricing of the risk if models have been underestimating the potential risk due to climate change.

There are also likely to be long-term implications for insurance customers impacting the availability and affordability of property insurance as a result of

[28] ABI Flood Re explained

the increased flood risks which may result in customers with no recourse to insurance to reduce their risk exposures. This may result in increased conduct and reputational risks for the insurer.

While flood risk is expected to be the most material physical hazard for UK insurers, other perils may also drive sizeable and unforeseen levels of loss, or claims volume, under climate change, especially for those with exposures concentrated geographically, or by risk type, in areas of greatest potential impact. In particular, the potential changes to UK subsidence risk due to changes in weather patterns, with projected drier, warmer summers, alongside more variable rainfall, can increase the potential for shrink-swell ground movements in clay rich soils. The UK Climate Change Risk Assessment 2017 Evidence Report sets out the priority change risks and opportunities for the UK which can be consulted for further details.

A recent British Geological Survey report[29] has indicated that the extent of potential subsidence areas is likely to increase from 3% of UK properties in 1990 to 10% by 2070 under a hothouse scenario.

While this does not immediately cause concern to property insurers given the frequency of claims likely from subsidence as well as the other contributing factors (property characteristics, vegetation etc.), some insurers with concentrations of exposures in the highest risk areas may need to consider potential impacts, particularly in respect to possible wet winter / dry summer years with accumulations of both flood and subsidence claims.

### What are the key features or parameters of the selected scenarios for the given use case?

The most relevant NGFS scenario from a physical risk perspective is the 'Hot House World "current policies" scenario' (where significant warming continues due to limited action to reduce emissions leading to strongly increased physical risk), although the physical risk trajectory is similar for all scenarios over the next 20 years given natural lags in the climate system. Thereafter the trajectories and effects diverge more. A Hot House World current policies scenario illustrates the effects most clearly.

Of all the physical risk from climate change, worsening flood risk is generally considered by the industry to be the most significant for UK insurers both domestically, and for those with international business (although other hazards such as windstorm, wildfire, hail, drought, and freeze will all experience changes in future frequency and severity under climate scenarios), as global warming intensifies and disrupts patterns in the water cycle. Flood risk arises both from more intense rainfall (e.g. in 24 hours or from one named storm) and from more prolonged and extreme wet seasons (e.g. several recent winters in UK). Regional and local changes in flood risk can be highly variable around the general trends, particularly in urban areas, where flooding can be influenced by demographic and surface drainage changes. There also still remains a lot of uncertainty on whether models adequately capture the large-scale circulation changes in a credible enough way to be confident that modelled outcomes represent the real-world outcomes.

[29] The British Geological Survey - Maps show the real threat of climate-related subsidence to British homes and properties.

It is worth noting that while they serve as a good starting point, the NGFS scenarios are not well suited to analysing physical risks, particularly for acute events. They do not represent acute risks fully, particularly at the tails, and this could lead to underestimation of risks if scenarios are built solely upon these. They are also not tailored to the UK and therefore need to be combined with other information for more representative results. In the case of UK flood, it is advisable to also draw on modelling some specialist vendors and also draw upon Met Office projections that are most suitable for the UK.

### How do the selected scenarios need to be enhanced or tailored for the given use case?

While used as a primary benchmark in many scenarios, average precipitation is not a relevant metric when assessing the potential for more extreme weather events. This creates a need to translate temperature pathways into increasing likelihood of relevant tail severity events. This is not simple and requires careful consideration.

There are different possible approaches to considering a challenge of this nature and an example of a possible approach is set out in the case study 1 shown above where 250 years of historical rainfall data patterns were analysed over 1-, 2- and 3-month rolling periods, and found the strongest signal was the increasing frequency of 3-month heavy winter rain (and a decrease in the summer months).

### How can the results of scenario analysis be effectively communicated internally and externally?

There are a range of potential audiences to consider when deciding how to communicate the outputs from the use cases. These include the Board and key strategic decision makers internally and externally, as well as regulators, investors and public agencies responsible for flood risk management.

One strategy successfully employed when communicating internally is to link weather peril analysis and modelling with climate trends and reinsurance strategy proposals, as a natural flow in one Board-level meeting.

It is important that any communications of the results clearly set out the inherent limitations of scenario analysis of this nature, including those relating to modelling techniques employed, data sources utilised and their applicability and reliability and the inherent uncertainties prevalent in modelling over such a long-time frame. These limitations are not set out to negate the value of the assessments but to contextualise them and provide context to the outputs. Where possible, sensitivity analysis of key assumptions should be used to help illustrate the potential range of outcomes.

Stress testing of any nature plays a key role in enhancing the understanding of Boards and key strategic decision makers on topics and this is particularly true of climate change. Consideration should be given to how results can be presented in a way that can enhance understanding and knowledge while still providing sufficient granularity, clarity and transparency to ensure it is fit for purpose.

There are also opportunities to utilise the outputs to influence a wider range of external stakeholders on issues like flood defence; the future of Flood Re or similar pooling mechanisms and other public policy decisions likely to introduce significant risks in the longer-term.

More information on how to effectively communicate the outputs of scenario analysis can be found in the CFRF Data & Metrics Report - Climate Disclosure Dashboard section.

## Data requirements

The areas considered below apply equally across each of the scenarios and where there are particular differences these are specifically identified.

### A. What are the data requirements?

Insurers existing flood maps and flood models continue to remain relevant, particularly to assess probable maximum loss potential as a tail risk metric. The inclusion of climate change assumptions into existing sophisticated flood models adds a further level of complexity, and uncertainty to the modelled outputs, but the fundamental data requirements remain the same, around the 'risk equation':

Risk = Hazard * Exposure * Vulnerability

While hazard will tend to be based around a combination of scientific, analytical and statistical methods to construct the best representation of the range of events likely to occur in a given region, the exposure and vulnerability elements can also vary with future climate change conditions.

Exposure is the representation of the assets at risk to the hazard. There is a fundamental level of attribution needed to properly represent exposure in respect to the calculation of value at risk. This is primarily related to property risks, and in particular, physically located assets such as buildings, and other insured structures or features. This requires geocoding the dataset of the portfolio of properties at risk, together with values at risk and other relevant property-level data (e.g. construction, flood prevention measures, local flood defences).

The calculation of loss at the portfolio level should also take account of subsequent risk transfer and protection, including the scale and nature of the assumed reinsurance programme in place, as this is important to understand the net potential tail exposures which the insurer will retain or be exposed to. Climate change can alter the effectiveness, availability and coverage of reinsurance and other risk transfer structures, and so any scenarios used should include the potential for meteorological trends to inform a shift over time in predicted frequency of a given tail event, including both portfolio and reinsurance considerations.

## B. What are the current approaches to access the data and metrics?

There are many proprietary flood models available for use and insurance companies are likely to have extensive experience of utilising such models, although most are developed to represent present day risks. There are some more recent examples of specially designed models which include climate change directly in the development of alternative hazard components (for example by altering the distribution of synthetic potential events to reflect expected changes in the size, distribution and frequency of events). However, other approaches can be used to approximate certain aspects of present-day calibrated hazard and loss models, for example by altering the frequency distribution of the events included in probabilistic models. This approach is useful as a means to 'stress' loss estimates to possible changes in the likelihood of tail events but will not fully represent the possible change in intensity or geographic location of events.

External specialist data providers can be utilised to enrich data sets where existing data is not considered sufficient.

It is important though that firms carefully consider the approaches and assumptions that underpin any models and ensure that the models and application of the scenarios are appropriate for the business decision being considered and the materiality of the risk exposure.

An example of one available flood model is set out below. This is to illustrate a possible approach and is not an endorsement of this model over any other, which is for firms to decide.

### Case Study 9: An external flood model example

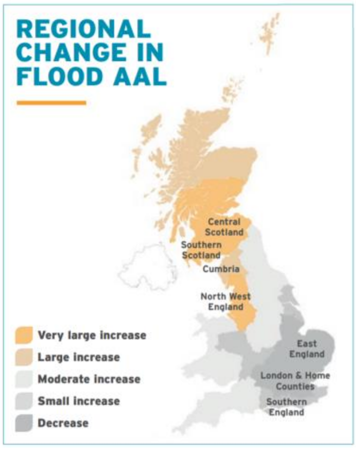
JBA released their first UK Climate Change Flood Model in 2018 to assess risk under a future climate scenario. By applying adjustment factors from the UK Climate Change Risk Assessment 2017 and UK Climate Projections 2009 (UKCP09), they statistically modified the local hazard intensity of each event within their UK Flood Event Set. This, combined with their 5m UK flood maps and 2018 UK Flood Model exposure data, means they were able to provide an indication of coastal, surface water and river flood risk across the country under a plausible warming scenario of 2°C by 2100, for the time slice 2010-2039.

By comparing results from their UK Climate Change Flood Model to those from their baseline UK Flood Model, JBA's modelling can offer an insight into the potential future change in financial loss and where in the UK the risk to flood may change. The results suggest an increase of between 25-30% in Average Annual Loss (AAL) for residential properties across the UK.

Interestingly, the results don't show an increase in flood risk and AAL everywhere, as shown in the summary results map below. For example, the greatest increases in AAL are anticipated in the north and west, whilst losses are projected to decrease compared to present-day in the southeast. Whilst this map shows the combined change in flood AAL, the pattern varies by flood type.

JBA will be releasing an update to their UK Climate Change Flood Model in 2022, including more recent climate data from UKCP18 and an enhanced method.

***Figure 24: Map: Regional change in annual average loss (AAL) for UK flooding***




*Source: JBA UK Climate Change Flood Model and JBA's residential market portfolio*

The results presented illustrate the broad regional differences in anticipated loss under a future scenario for river, surface water and coastal flooding combined based on JBA's national residential market and derived from UKCP09 and UK CCRA 2017 data. At the national level, the JBA model estimates a 25-30% increase in Annual Average Loss (AAL) to residential properties for a moderate emissions scenario by 2040. At the more detailed level of model outputs, there will be wide variations in the estimated relative change between river, coastal and surface water, and by geography. The relative contribution of each flood type to overall AAL will vary dependent on the type of exposure and detailed location. Insurance risk scenario analysis will tend to apply the model to a detailed (e.g. location) resolution of exposure data.

There is limited data available to directly link longer-term climate trends to changes in frequency of tail events. Research into relevant meteorological trends in severe or prolonged precipitation events can be utilised in order to inform a shift over time in predicted frequency of a given tail event. An example of such an approach is set out above.

## C. What tools are available?

The availability of climate-conditioned flood (and other hazard) models is increasing, but these will only provide one aspect of the wider climate impact assessment required to determine overall risks to insured portfolios, and particularly in respect to non-property lines of business. Indirect and intangible impacts should also be considered within a wider 'transmission channel'[30] approach where causal links are identified for both tangible, direct impacts such as physical damage, site specific business interruption to properties, as well as less tangible, indirect impacts such as supply chain impact, commodity price change, consumer sentiments, and policy changes.

[30] Basel Committee on Banking Supervision Climate-related risk drivers and their transmission channels (Chapter 3).

These approaches can enable consideration of relative materiality of both quantitative and qualitative impacts. For the risk elements of insurance balance sheets, it is also important to understand the impact of policy wording and consequent exposure against the full range of possible impacts.

## D. What are the key barriers to overcome, and options to address them?

The key data barrier to overcome is quantifying climate trends in terms of a change to the probability distribution of specific flood risks.

There is limited data available to directly link longer-term climate trends to changes in frequency of tail events. Research into relevant meteorological trends in severe or prolonged precipitation events can be utilised in order to inform a shift over time in predicted frequency of a given tail event. An example of such an approach is set out above.

# 6. Portfolio alignment and construction

This section focuses on the use of scenario analysis to explore alignment of financing portfolio(s) with the objectives of the Paris Agreement. It also provides guidance to help utilise scenario analysis to aid portfolio construction. To be consistent with the scope of the transition and physical risks' sections, we are focusing on a bank's loan book[31].

It may be helpful to read this section in conjunction with the CFRF Data & Metrics Report –Climate Disclosure Dashboard section. The Climate Disclosure Dashboard situates this discussion in a wider disclosure/use case context while this section provides more detail on how to tackle portfolio alignment metrics.

## Assessing alignment of the corporate lending portfolio to a low-carbon transition scenario for banks

Alignment is distinct from transition and physical risks assessment in that the former explores the potential contribution of the bank's balance sheet/investments to climate change, while the latter explores the impact of the climate on the bank.

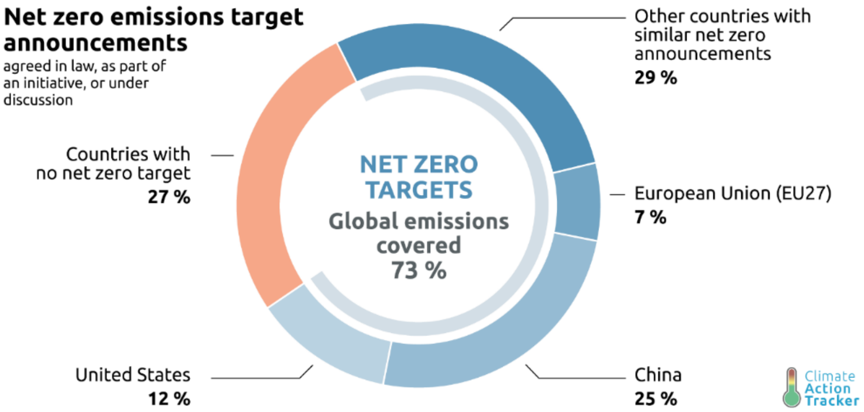
The starting point for any bank is to define what the alignment objective or target is: Is the intent to align financing portfolios with a "below" 2°C outcome, or a more ambitious 1.5°C outcome? Or is it about achieving Net Zero emissions and by what date should that target outcome be achieved? Given that the Paris Agreement temperature outcomes (i.e. 2100) are beyond any realistic planning horizons, a bank will need to determine or define interim alignment targets to steer the financing portfolio towards the target objective.

Once a bank has defined the target, it will need to determine what its current starting point is (i.e. how far out of alignment is the current financing portfolio?) and which financing activities and sectors they will include in the scope of their alignment objective: Is the focus on lending only? Or lending and capital markets activity? And which sectors should be included?

On this last point, there are broad parallels between measuring alignment and conducting a scenario analysis to measure transition risk in that the sectors of focus will be the most carbon intensive and require the greatest degree of transition. It should be noted that the two concepts are not synonymous since it is possible for a company to be exposed to transition risk while being aligned to a 2°C pathway and vice versa; for example, a services company may have low emissions but derive all its business from a sector exposed to transition risk. As a result, banks will be able to disclose their strategy for portfolio alignment in the context of the Paris Agreement using forward looking metrics, and also contrast against their resilience to transition and physical risks.

[31] It should be noted that several banks who have made Paris aligned or Net Zero commitments have also included capital markets activity.

***Figure 25: Net Zero emissions targets have now been announced or ratified into law by countries representing 73% of global emissions.*** [32]



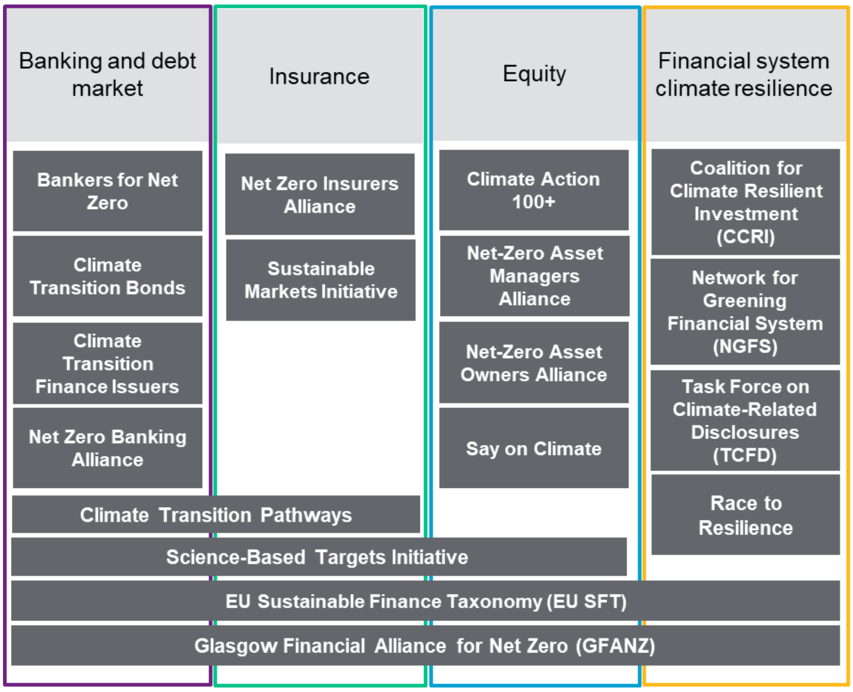

Internationally, there is growing commitment from policymakers to improve emissions alignment with the Paris Agreement. This has manifested in mostly long-term Net Zero targets by 2040-2060.

If these "optimistic" commitments are met (plus unsubmitted changes to NDCs) then we would experience 2.0°C warming by 2100, with the Paris Agreement target of holding temperature rises to 1.5°C becoming more attainable with further action.

Amongst financial institutions, there has also been a growth in alliances and coalitions to commit to Net Zero targets which encompass their relevant investment capital portfolio(s), with particular focus on aligning to a 1.5°C pathways (see Figure 26).

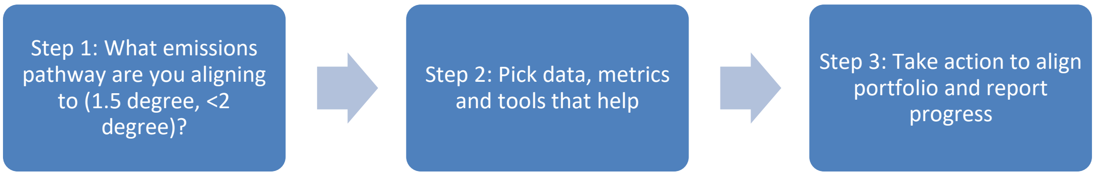
[32] "Global Update: Climate Summit Momentum", Climate Action Tracker, May 2021 "Paris Agreement Turning Point", Climate Action Tracker, Dec 2020

*Figure 26: Some of the initiatives advancing alignment across financial institutions and corporates*




## Approach to alignment and portfolio analysis

*Figure 27: Steps to analyse the risk in alignment, banks need to go through a staged process.*




### Step 1: What emissions pathway are you aligning to?

It is important to first understand what you are trying to align to. One key aspect of the Paris Agreement is that parties should commit to limiting warming to well below 2°C and make efforts to align with 1.5°C. Many of the initiatives mentioned in Figure 26 involve signatories committing to align their financial portfolios to the 1.5°C pathway as this involves the least amount of socio-economic disruption due to physical changes in the climate.

Once you have decided on an appropriate level of ambition, it is also necessary to identify an appropriate scenario against which to measure the current starting point and future progress (see Figure 6, Section 2.2 for options from GARP survey). The recent publication by IEA of a Net Zero scenario[33] provides one such option across the economy, albeit somewhat

[33] "Net Zero by 2050", IEA, May 2021.

disorderly. Alternatively, banks could consider the NGFS scenarios, such as the orderly scenarios of "Net Zero by 2050" or "Below 2°C".

Unlike the analysis described in transition and physical risks sections which are used to assess resiliency and financial risks against a high transition and high physical risk scenario, the objective here is to determine an appropriate target, determine the current baseline starting point and define how to demonstrate progress in aligning to the chosen specific scenario and deviation from a particular pathway.

It should be recognised that there is not a single pathway to 2°C, 1.5°C or, for example, Net Zero by 2050. Each of those target outcomes could be achieved in myriad ways. For example, the IPCC identify two main types of pathway to a 1.5°C warmer world: one stabilizes global temperature at, or just below, 1.5°C; the other has global temperatures temporarily overshooting 1.5°C before coming back down. The latter involves much more significant risks to natural and human systems.[34] Therefore, it is important to build in a degree of sensitivity testing to measure a portfolio's resilience under a selected pathway. By doing this, the institution can better understand own vulnerabilities and potentially inform the development of a bespoke approach that better suits a particular bank's portfolio concentration and construction.

**Step 2: Select metrics that are most relevant and analyse your portfolio**

Using the alignment scenario can inform which sectors should be prioritised, which is likely to be the most carbon intensive sectors with defined decarbonisation pathways. A bank will need to decide what the most effective measure of decarbonisation is: carbon intensity or absolute carbon emissions. Common, comparable metrics need to meet the following criteria for them to be useful[35]:

- **Forward looking**: to communicate a direction of travel and give credit to credible efforts by companies to decarbonise
- **Decision useful**: allowing comparisons of companies and portfolios with peers, tracking progress over time, and incentivising transition
- **Robust**: analytically rigorous and consistent with climate science
- **Broad coverage**: across sectors, assets, and end users
- **Actionable**: methodologically transparent and feasible given data requirements

Principles for selection of climate related metrics are discussed in further detail in the CFRF Data & Metrics Report –Climate Disclosure Dashboard section.

The current approaches to looking at either a company or portfolio alignment consider the following types of metrics:

[34] IPCC Special Report: Global Warming of 1.5ºC
[35] "Measuring Portfolio Alignment", Portfolio Alignment Team [of banks], Nov 2020.

***Table 2: Metrics useful to consider in portfolio alignment***

<table>
<tr><th>Type of metric</th><th>Company level</th><th>Portfolio level</th><th>Commentary on metric and use</th></tr>
<tr><td>Short & medium-term emissions reduction targets aligned to Paris Agreement e.g. Science based targets (SBTs)</td><td>Does the company have a Paris-aligned emissions reduction target (SBT)?</td><td>% of portfolio with SBTs</td><td rowspan="2">+ Demonstrates whether alignment with science exists by company.<br>– Binary. Does not indicate how far away those companies/ portfolios without targets from alignment are<br><br>Considerations: by incorporating baseline year and size, rate and scope of decarbonisation, it is possible to show more differentiation between companies across their target's ambition and alignment, particularly when falling short of an SBT.</td></tr>
<tr><td>Long term emissions reduction targets (Net Zero)</td><td>Does the company have a Net Zero target that is not reliant on carbon offsetting long term?</td><td>% of portfolio with Net Zero targets that do not rely on offsets to reach zero</td></tr>
<tr><td>Deviation of portfolio from a target or benchmark metric</td><td colspan="2">Examples are provided in e.g. TPI[36], ACT[37] or as part of the models used in Table 3 below etc. and include deviation from Scopes 1, 2 and/or 3 emissions reduction targets alignment with 1.5°, well-below 2° (WB2D), 2° or other scenarios</td><td rowspan="2">+ Gives a quantified assessment of a company / portfolio's deviation from Paris / climate science alignment<br>– More sophisticated analysis needed: data coverage and outcomes will be difficult to compare as dependent upon models used, data, etc…</td></tr>
<tr><td>Degree warming / temperature rating metric</td><td colspan="2">A specific type of deviation metric that calculates the implied temperature rise associated with a portfolio. See Table 3 below</td></tr>
</table>

Conceptually, the most sophisticated and decision useful approach to measuring alignment is to calculate a temperature rating (referred to elsewhere as an Implied Temperature Rise - ITR) of a portfolio, although there are methodological challenges in conducting this analysis. Irrespective of the approach pursued, measuring alignment includes the following steps:

a. Measuring the climate performance of a company or portfolio.
b. Choosing one or several decarbonisation scenarios to which the portfolio will be compared.
c. Converting the decarbonisation trajectories from the scenarios chosen in step 2 to temperature alignment benchmarks that are comparable for the specific companies, sectors or portfolios under consideration.
d. Comparing the results of step 1 and step 3 to produce results which are expressed through an indicator, such as an implied temperature rise metric.

However, temperature ratings are not without caveats as methodologies and data used differ and can produce different results. Readers can consider exploring the Portfolio Alignment Team report which breaks down a temperature alignment metric into nine key building blocks[38] and the subsequent TCFD technical supplement.[39] For a detailed review of existing methodologies, we also recommend the analysis by the Institut Louis Bachelier et al[40].

[36] Transition Pathway Initiative methodology.
[37] Assessing low-Carbon Transition (ACT) methodology.
[38] Measuring Portfolio Alignment: Assessing the position of companies and portfolios on the path to net zero, November 2020.
[39] "Measuring Portfolio Alignment: Technical Supplement", TCFD, July 2021.
[40] Institut Louis Bachelier et al. (2020). The Alignment Cookbook - A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low-carbon Trajectories or Temperature Goal.

A sample of existing temperature rating providers from this analysis is given below:

***Table 3: Data providers for alignment relevant information– source "The Alignment Cookbook" (2020)***

| | ARABESQUE* | CARBON 4 FINANCE | CDP-WFF TEMPERATURE RATING | ECOACT | URGENTEM | I CARE & CONSULT | ISS | MSCI CARBON DELTA** | RIGHT BASED | S&P TRUCOST | 2* INVESTING INITIATIVE PACTA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| METRIC | GHGs | GHGs | GHGs | GHGs | GHGs | GHGs | GHGs | GHGs | GHGs | GHGs | Technology GHGs |
| PERIMETER | Scope 1 & 2 | Scope 1, 2 and 3 where relevant | Scope 1, 2 and 3 where relevant | Scope 1 and 2, inclusion of Scope 3 indirectly | Portfolio: full value; sector & company: Scope 1 | Scope 1, 2 and 3 where relevant | Scope 1, Scope 3 for oil & gas | Scope 1 | Scope 1, 2 and 3 | Scope 1 and 2. Scope 3 for oil & gas and automotive | Scope 1, 2 or 3 where relevant |
| SECTOR COVERAGE | High | High | High | High | High | Average; high with a combination of methods | High | High | High | Average; high with a combination of methods | Average |
| POSITIVE IMPACT | No | Avoided emissions | No | No | No | Specific trajectories for "enabling" products & services | No | No | No | No | Specific trajectories for green share |
| FORWARD-LOOKING | Fixed (no forecasts) | Qualitative score taking into account multiple data points | Targets | Targets | Fixed (no forecasts) | Combination (targets, historical trends) | Combination (targets, historical trends) | Low-carbon revenue forecasts | Depends on method: extrapolation; targets | Combination (targets, historical trends, asset-level datasets) | Asset-level data |
| SCENARIO | IEA ETP | IEA ETP | IPCC | IPCC | User-defined (IPCC, ETP) | IEA ETP | IEA ETP | NDCs, UNEP Gap report | User defined - IEA ETP | IEA ETP; IPCC | User defined - IEA ETP |
| BENCHMARK TYPE | Economic intensity; absolute (trend indicator) | Score | Multiple to match company targets format | Absolute emissions | Portfolio: intensity; sector & company: absolute | Physical intensity | Economic intensity | Economic intensity | Economic intensity | Physical intensity; economic intensity | Absolute technology exposure |
| ALLOCATION | Sector-specific convergence | Sector-agnostic convergence | Sector-specific/ agnostic contraction | Sector-agnostic contraction, sector-specific | Sector-agnostic/ specific contraction | Company-specific convergence | Company-specific convergence | Sector-specific convergence | Sector-specific contraction | Company-specific convergence; overall contraction | Company-specific contraction/ expansion |
| TIME HORIZON | 2030 and 2050 | Undefined | Target base year to 2025-2030; to 2030+ | Undefined: Target time horizon | 2015-2060 | 2010-2050 | 2018-2050 | 2030 | 2018-2050 | 2012-2025 (T+5) | 2018-2023 (T+5) |
| ALIGNMENT TYPE | Point-in-time gap | Point-in-time gap | Trend | Trend | N/A | Cumulative over (under) shoot | Cumulative over (under) shoot | Point-in-time gap | Cumulative over (under) shoot | Cumulative over (under) shoot | Trend |

*Methodology details and results presented use Temperature Score V1.1, to be released by Q3 2020.
** Currently working on updates: integration of Scope 2 and 3, company targets, aggregation of sector-specific and sector-agnostic temperatures and framework to include future low-carbon revenues.

Besides temperature warming metrics, several banks are developing their own proprietary alignment methodologies too. These methodologies typically involve many of the same building blocks as a temperature warming metric, and centre around measuring either the absolute emissions or intensity associated with a portfolio and comparing this to a future decarbonisation pathway. Several banks are also using different scenarios for measuring alignment, such as those by the International Energy Agency (IEA), which typically provide additional granularity on sector-level decarbonisation trajectories.

Whichever approach is taken, design judgement will also need to take into account the availability, quality, coverage and granularity of data available upon which to assess the portfolio, plus the inherent deviation in results of different models. This is a developing field so we would also recommend being cognizant of the underlying assumptions and shortcomings of the models being used.

**Step 3: Take action and report**

Once you have analysed where your financing portfolio is aligned to, you then have a number of options.

**Option 1:** Immediately reduce / manage loan exposure: this may involve imposing restrictions on new lending or onboarding of new clients who are out of alignment with the chosen pathway whilst winding down and/or reducing exposure from existing clients who are similarly out of alignment.

**Option 2:** Gradual adjustment of loan exposure: similar to option 1, this involves setting timeframes to reduce exposures to clients that are out of alignment with the selected benchmark targets.

**Option 3:** Transitioning of your portfolio: enable clients to commit to changing business models and asset mix in line with the alignment objectives through provision of financial products/services.

The first of these options enables you to temperature align, decarbonise and de-risk a portfolio relatively quickly and sends alignment signals to the market by choosing to only lend to clients whose business models align with the selected benchmark targets. However, it has downsides since it restricts your immediate choice of clients to those that currently meet your alignment criteria. These downsides include:

a. assumes that there are sufficient companies which are appropriately aligned;
b. makes little impact on the wider economic risk from climate change. Secondary and tertiary effects may cause the climate-related risk to be disguised or hidden in your portfolio[41];
c. leaves clients little time to understand, adapt to- and implement changes to business models.

Option 2 is a more orderly glidepath approach to decarbonising a portfolio

[41] Secondary and tertiary effects arise when an investment is discontinued in your portfolio (e.g. loan to company A) but may continue to raise finance elsewhere (e.g. through trading with other companies in your portfolio and that are reliant on trade with company A to meet debt repayments).

than option 1. It has the advantage over option 1 that it both gives more time for companies to meet alignment criteria and also allows banks more time to implement policies. However, neither of options 1 nor 2 will necessarily achieve the overall objectives of Paris alignment as they implicitly shift the risks to elsewhere in the market.

Option 3 is to work with clients, including through providing products and services, and collaborate with clients to retire carbon intensive assets, improve emissions efficiency of existing assets, whilst encouraging the proliferation of low-carbon goods and services. Naturally, this option requires greater engagement with clients and a systematic assessment of eligible financing opportunities.

Finally, in order to demonstrate portfolio alignment to a wider group of stakeholders, banks can consider using the PCAF reporting standard for banks[42] to generate reports on emissions that are financed by a portfolio. This can help when comparing to "Net Zero" or similar targets.

We recommend that banks focus on a staged approach of asset classes. For alignment purposes, scenario analyses need to be focused on the asset classes where there is likely to be the largest emissions profile. These asset classes include corporate loans & debt to high carbon sectors, sovereign debt where fossil fuels[43], cement and steel play a large part of the economy and retail (mortgage to houses with low EPC ratings and SME loans).

### What time horizons should be considered?

Alignment by its nature considers the short, medium and long term. The focus on long term Net Zero targets by 2050 will not avert the worst impacts of climate change if the trajectory of the commitment is also not in line with scientific consensus.

As such, alignment policies and metrics should therefore be constructed such that decarbonisation and/or stewardship occur across medium (2025 – 2035) and long (2035–2050) timescales. For example, ING have provided an overview that shows both long term goal and progression over time compared against the IEA's SDS and NZE2050 scenario trajectories[44]. They narrowed down their alignment metrics in line with the Katowice commitment for this sector to be:

1. An absolute reduction in fossil fuel finance
2. A relative reduction in fossil fuel finance
3. A transition towards lower-carbon fossil fuel extractive processes[45]

The diagram below illustrates the alignment for the metric of absolute financing of upstream oil & gas.

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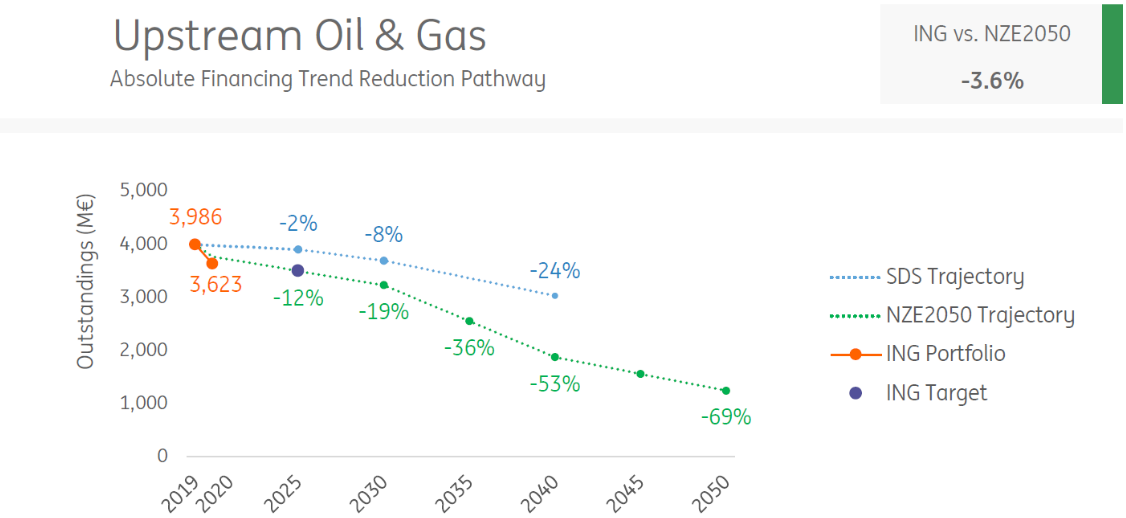
[43] An example analysis of the extent transfer of corporate risk to sovereign risk was given by the Climate Policy Initiative for the South African economy.
[44] ING Terra approach.
[45] This third metric, which tracks transition towards less carbon-intensive ways of extracting fossil fuels, is still under development. ING currently discloses the first two metrics (see 2021 Climate Report, pages 55 and 56).

*Figure 28: Upstream Oil & gas finance reduction pathway for ING against IEA's SDS scenario*[46]




This financing metric could additionally be broken down into more nuanced alignment categories. For example, the EU Sustainable Finance Taxonomy has produced a list of activities and technologies that could be labelled as transition technologies, with potential expansion of the taxonomy expected in 2021.

*Table 4: Breaking down fossil fuel production activities by emissions impact*

| Financing activities which could increase emissions and deviate away from alignment | Financing activities which could stabilize or prevent further emissions (neutral or incremental effect on alignment) | Financing activities which could reduce emissions and transition the portfolio / company (positive effect on alignment) |
|---|---|---|
| New exploration and production | Making operations more efficient & reducing emissions (e.g. CCS, fugitive and flaring prevention) | Carbon removal technologies (e.g. CCS, BECCS) |
| Expansion of current exploration and production | Decommissioning "high carbon" assets | Alternative fuel / energy finance to displace fossil fuel assets |
| | Alternative fuel / energy finance as additional assets | |

Further case studies and guidance for aligning portfolios including the oil & gas industry can be found in the Portfolio Alignment Team's report and in the TCFD technical supplement on portfolio alignment.[47,48]

## Utilising scenario analysis to aid portfolio construction for insurers and asset managers

For investors, the value of climate scenarios lies primarily in their implications for security prices. How might a company's share price perform in a 1.5°C scenario compared with a 3°C scenario? How will these scenarios impact the

[46] ING 2021 Climate Report
[47] Measuring Portfolio Alignment: Technical Supplement", TCFD, June 2021
[48] Measuring Portfolio Alignment", Portfolio Alignment Team, Nov 2019

price of its bonds? What are the implications for my portfolio as a whole?

To deliver climate scenario analysis capabilities effectively and achieve the desired outcomes, the right resources need to be in place with the relevant knowledge and skillsets to enable decision-making. For most financial institutions, the complexity, cost and resource-intensity of developing in-house climate scenario modelling capabilities requires working with external partners. The following suggestions can help the institution in this direction:

- Identify and design the scenarios most relevant for assessing climate-related risks and opportunities.
- Translate the scenarios into direct shocks such as carbon taxes or physical damages to infrastructure, and indirect impacts such as changes to commodity prices and patterns of demand.
- Estimate the effect of shocks on asset value streams accounting for exposure to different shocks, adaptation or mitigation by companies, and the nature of competition within an industry.
- Convert these asset-value-stream projections into 'fair value' impairment estimates.

The guidance that follows is based on extracts from a white paper on the topic published by Aberdeen Standard Investments in February 2021. Further details, including details on the methodology underpinning the analysis presented can be found here.

## The importance of scenario design and choice

The first important choice an institution has to make is how to design the baseline scenario (see section 3.2) as security impairment estimates are generally expressed relative to that baseline. In the case of portfolio construction, this should usually resemble the pathway for climate change and climate policy that the market, in aggregate, is pricing at the time of the exercise rather than what the institution thinks is most likely. That ensures that the asset pricing implications of a given scenario are clearly articulated.

However, in other portfolio construction use cases alternative baselines may be more appropriate. For example, where assets are held to maturity and not subject to fair-value accounting then consideration of the baseline that an institution considers most likely may be more appropriate.

Moreover, when it is not possible for an institution to design and implement a 'market pricing' baseline, an alternative that can be easy to interpret is the maintenance of current policy or the aggregation of countries nationally determined contributions to the Paris Agreement. However, the user should keep in mind that it is harder to interpret and model the asset pricing implications of a given scenario the farther away a baseline is in relation to how the market is priced.

The second, and equally important choice an institution has to make is about which alternative scenarios to include in the exercise. This choice set has the potential to be quite different when the use case is portfolio construction rather than stress testing a portfolio. For the latter, scenarios will be chosen from the tails of the climate-related probability risk distribution – extreme physical risk

(Hot House World in the NGFS exercise) – or extreme transition risk (Disorderly or Orderly in the NGFS exercise).

For portfolio construction, however, it is important to capture the likely course of climate change and the energy transition, or the central tendency of the probability distribution, because that is what asset prices will align with over the longer-term.

When considering how to select and design likely scenarios or scenarios with a high probability of actually occurring, the user should take into account that:

- The political economy and economics of climate change mitigation is likely to vary significantly across geographies and sectors.
- Climate-related policy and low-carbon technology pathways are difficult to forecast over long horizons. Accordingly, there are a wide variety of plausible ways in which energy-usage patterns might evolve in the future.
- Approaches to scenarios that assume uniformity of policy across geographies and sectors, or that are based on a single view of future technological change, may generate misleading results about the probable absolute and relative impact of mitigation policies across the universe of securities and indices.

This points towards the benefits of users wanting to incorporate scenario analysis into portfolio construction by designing 'bespoke' scenarios, as a complement to existing off-the shelf scenarios (e.g. drawn from the IIASA scenario explorer) that:

- Avoid implausible assumptions of policy uniformity across sectors and geographies.
- Allow a probabilistic approach to scenario design and impairment estimation to be taken.
- Facilitate regular adaption of scenarios and probabilities to changes in the underlying political, policy and technology drivers of climate change and the energy transition.
- Are tailored to the specifics of the portfolio.

This approach also implies significant benefits to drawing on a large number of potential scenarios, so as to fill in as much of the probability distribution as possible.

Note, however that incorporating 'bespoke' scenarios into analytical frameworks should be seen as a complement to, rather than a substitute for, 'off-the-shelf' scenarios like the ones provided by the NGFS or others that are drawn from the IIASA scenario explorer. *(*See Figure 29 below for the Aberdeen Standard Investments (ASI)/Planetrics approach*)*. That is because drawing on off-the-shelf scenarios makes it easier to benchmark analysis against the results of other users of climate scenarios. Off-the-shelf scenarios are also useful when the purpose of the analysis is to incorporate tail scenarios into portfolio construction, either because the user considers them likely or is building a portfolio solution around that scenario.

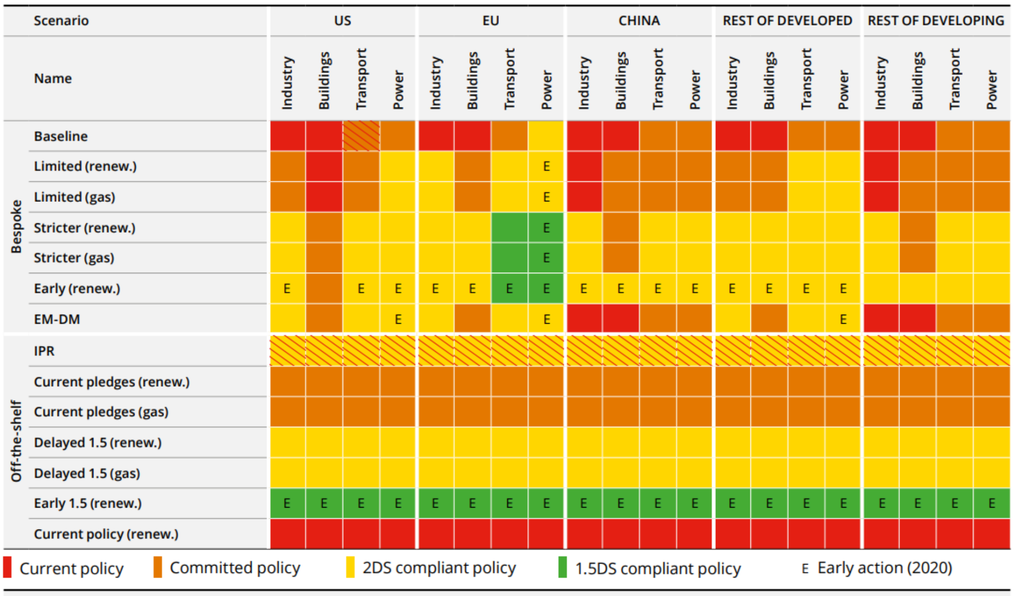
Off-the shelf scenarios may also be most appropriate for financial institutions towards the beginning of their analytical journey, which lack the resources and expertise to consider more complex options. Off-the shelf scenarios allow firms to start relatively simply and then build on the learnings over time which may be the most efficient way to utilise limited resources.

In order to illustrate how bespoke scenarios can be combined with off-the-shelf scenarios we describe below an approach developed by ASI/Planetrics as well as some of the conclusions that were drawn from that specific analysis by ASI. When considering this or the output from any other scenario climate analysis it is very important to bear in mind the inherent model risk associated with this type of exercise.

The CFRF Scenario Analysis Guide published in June 2020 identified the following challenges associated with climate modelling: the breadth and magnitude of transition and physical risks; the extended and uncertain time horizons and feedback loops; the weakness of many climate economic models; lack of representation of more complex non-linear impacts and tipping points (including acute physical risks); data gaps and comparability of disclosures; and cognitive bias.

The results of any analysis for individual firms and sectors are very dependent on the assumptions made in the modelling and the baseline chosen. When communicating and interpreting the results it is important that any weaknesses and limitations of the analysis are clearly communicated as well as the sensitivity of the analysis to key assumptions.

***Figure 29: The ASI/Planetrics climate scenario analysis incorporates a bespoke approach to complement the off-the shelf scenarios***




ASI, January 2021

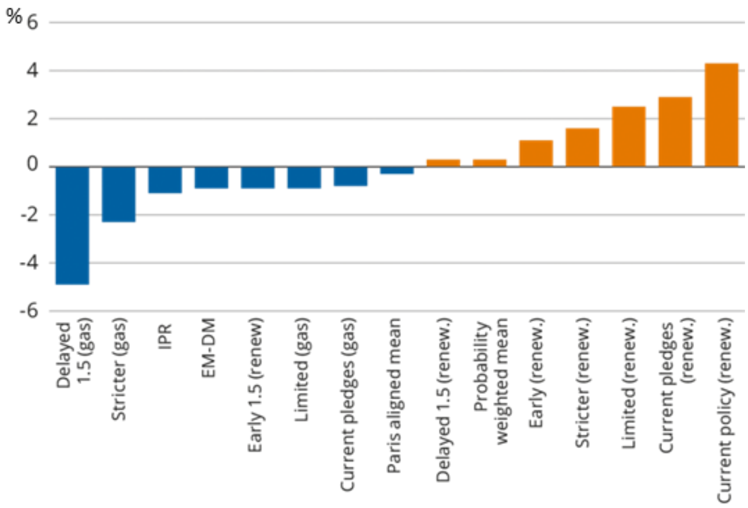
## **The financial impacts of the energy transition are likely to be highly dispersed across securities**

For those choosing to design their own scenarios, the probability weights assigned to each scenario can be multiplied by their respective energy-usage patterns, carbon prices and temperature changes to generate probability-weighted summaries of the inputs that underpin the estimates for financial-security impairments and ultimately incorporation into investment decision making.

Armed with their selection of scenarios, the user can then estimate their potential financial impacts, noting that estimated valuation changes for securities relate to stylised climate scenarios rather than a specific, concrete state of the world as it pertains to all of the factors that might affect the future revenue, earnings and realised value of the company. As such, impairment estimates should not be regarded as either forecasts or projections or represent investment recommendations of any kind.

Estimates by ASI (2021) suggest that, at the highest level of aggregation – the MSCI World index – the impairment and uplift differences between scenarios is likely to be relatively small *(*Figure 30*)*, even between the tail scenarios with the strongest climate-mitigation action and the largest changes in the energy mix compared with the baseline. That is because of the diversified nature of most large-cap equity indices, which implies that the large negative effects on many individual securities are mostly offset by positive effects on others.

***Figure 30: At the MSCI World index level, impairments are generally modest***




MSCI World Index-level total impact across all scenarios (mean-weighted by market cap, relative to what is priced into the baseline). ASI, January 2021.

This is an important result as it implies that, from an aggregate financial perspective, there is little need for diversified investors to fear the energy transition; at least over the long run, as long as they avoid firms that cannot or choose not to adapt their business strategies appropriately.

Of course, over shorter horizons, investors still need to tread carefully because the energy transition, the market pricing of that energy transition and asset owners' willingness to hold carbon-intensive assets, may not proceed in a smooth, linear fashion. Indeed, it is instructive that from a transition perspective the scenario that is worse for aggregate equities involves strong but delayed and therefore more disruptive policy action (the "Disorderly" scenarios).

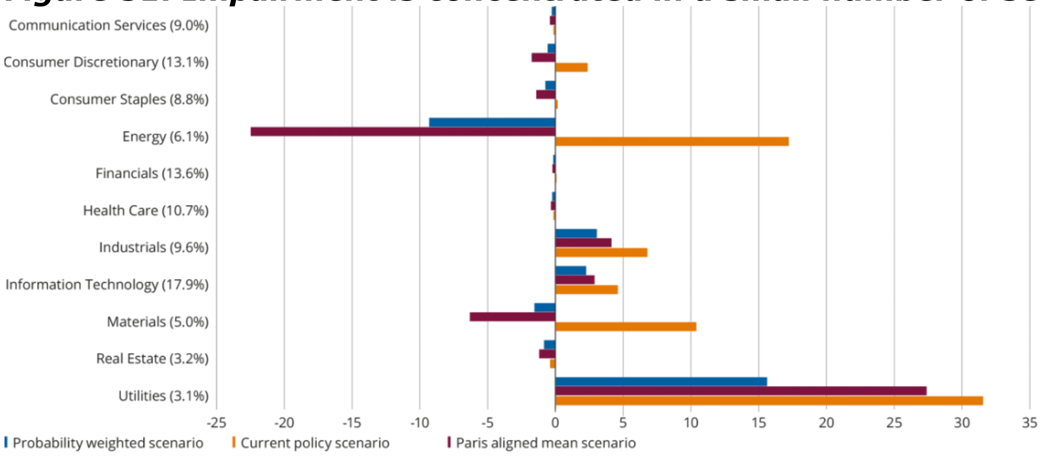
A continuation of current policy generates the most positive aggregate effects from a transition perspective. Relative to a baseline in which some transition risk is already factored into market prices, existing fossil-fuel-intensive firms do not face higher costs or weaker demand, and the current composition of indices does not capture the upside of smaller green companies that might grow into the index.

However, this scenario is obviously associated with the largest physical climate impacts and risk. The aggregate financial impacts of this physical risk are likely to be modest over the coming decade but become much larger over the longer-term. And unlike transition risk, physical risk is unambiguously negative for the global economy, with the negative effects likely to be felt across a broader range of securities than transition risk.

The generally small index-level impacts arising from energy transition in the central scenarios might lead some users to conclude that climate transition risk is not very material. However, these 'world-level' results hide large amounts of variation between sectors, sub-sectors and the firms within those sectors. This is largely driven by differing company-level exposures to demand changes and carbon costs. This dispersion is critical for identifying where risks and opportunities lie.

The most materially negative sector-level effects tend naturally to be concentrated in the fossil-fuel intensive energy sector and positive effects are usually concentrated in the utility sector *(*Figure 31*)*. This is because electrification of the transportation and other major energy usage sectors, leads to significant demand creation for many utilities. And the utility sector also has a much greater ability to pass higher carbon costs on to end-users – especially renewable operators, who benefit from the price uplift derived from carbon pricing but without facing any of the costs. Other sectors are more or less unaffected in aggregate. Under current policy, impacts for those sectors that are negatively affected under stronger climate-policy-action scenarios are usually the mirror image from a transition perspective. However, a sector's exposure to physical risk is not particularly correlated to transition risk, so depending on the sector this affect may be offset by negative physical risk impacts.

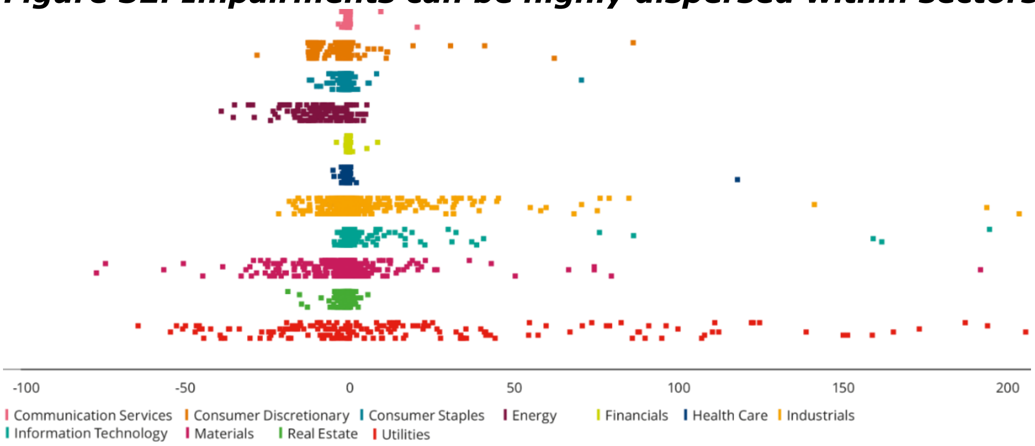
***Figure 31: Impairment is concentrated in a small number of sectors***




Comparison of sector-level impact (%) or impairment (means-weighted by market cap, relative to what is priced into the baseline) under three scenarios. Bracketed percentage shows the sector weight within the aggregate index. ASI, January 2021.

Critically, sector averages often say little about how an individual firm is likely to be impacted under a given scenario. Indeed, significant firm-level dispersion is evident in almost all sectors, with many instances of negative impairment in sectors that are on average positively affected in this mean scenario (and vice versa) (Figure 29). The utilities sector is perhaps the best (but not the only) example of why investors should not focus too much on sector aggregates. Within the sector there are many different types of firm with different levels of reliance on revenues derived from fossil fuels. In transition scenarios therefore, more fossil-fuel-reliant firms suffer in both absolute and relative terms, while the reverse happens in current policy scenarios.

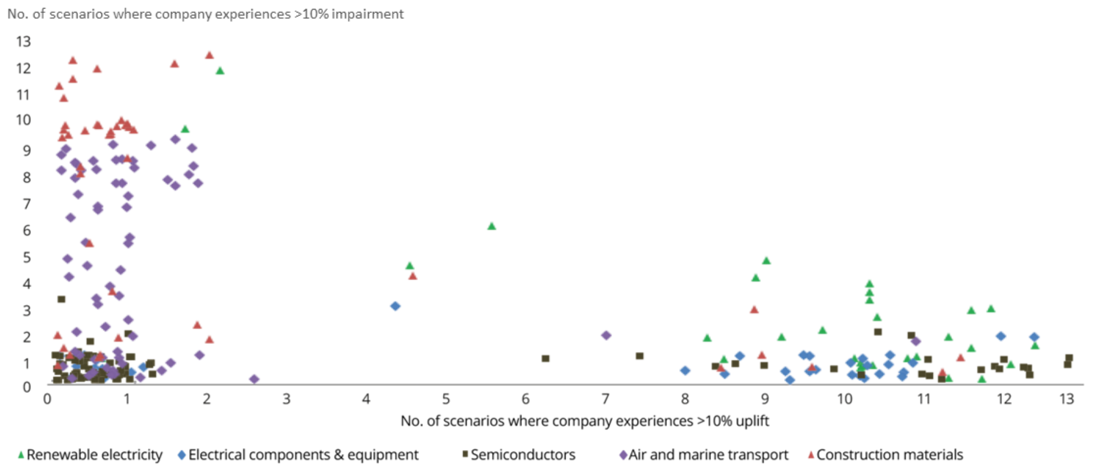
***Figure 32: Impairments can be highly dispersed within sectors***




Dispersion of total impact across all companies in the MSCI World index for each sector (probability-weighted mean scenario). Outliers beyond 200% are not shown. ASI, January 2021.

Different technology pathways also influence the nature of climate-related risk and opportunity and hence optimal portfolio construction. For example, technology pathways that favour renewable energy penetration over negative emissions technologies like carbon capture and storage generate much stronger demand creation for producers of semi-conductors. The upshot is that investors will need to rapidly respond as evidence accumulates as to who the technology winners and losers of the energy transition are (Figure 33).

***Figure 33: Resilient winners and common losers***




Distribution of uplift and impairment across selected sub-industries. ASI, January 2021.

Similar conclusions can be drawn by allowing climate policy to vary across regions and the major energy-usage sectors within those regions. For example, if climate-policy action in Emerging Markets is likely, on average, to be smaller in scale and more delayed compared with the advanced economies, the average EM firm in the sector would experience less negative impairment, consistent with it experiencing higher demand for oil and gas relative to the baseline and lower direct carbon costs.

### Scenario analysis has important implications for optimal micro and macro portfolio construction

Climate-scenario analysis helps provide a quantified foundation for forward-looking assessments of the risks and opportunities of different climate scenarios. However, this is still just a starting point for climate-related portfolio construction because companies are not now and will not in the future, respond in the same way to climate-related risk and opportunity, while the market is also continuously updating its assessment of the most likely path for climate change and climate policy and the appropriate value of affected securities.

The upshot is that the results of climate-scenario analysis should inform but not dictate investment decisions. Stock-level assessments need to be adjusted based on users' understanding of the company and the transition and adaptation plans it has in place. Discussing and validating some of the results highlighted by climate-scenario analysis with investee companies is an important part of the process.

It is also important to note that how the results of climate scenario analysis are used will also depend on whether you are the asset owner, or investing on behalf of policyholders, or managing assets for clients. In the former case you are the decision maker and can not only use your influence as a shareholder to engage and encourage companies to transition to a low-carbon economy, but also limit exposure to carbon intensive sectors and companies. In the latter two cases, clients have the final say as to where their funds are invested.

However, in these cases, firms can still take into consideration the results from climate scenario analysis in the investment process, in order to deliver long-term sustainable and superior investment outcomes for customers while adhering to their mandate. Firms can also offer policyholders and clients climate conscious products and funds, including default strategy options in the case of pensions, and engage with investee companies, and use voting rights, on behalf of policyholders and clients, to encourage them to transition to a low-carbon economy.

Nevertheless, even taking these caveats into account, scenario analysis is likely to lead to changes in investment decision making and portfolio construction. For example, from a strategic asset allocation perspective, aggregate forecasts for equity and bond indices are unlikely to change significantly. But large sector valuation impacts, and even larger company impacts, can make a substantial difference to the strategic asset allocation forecasts, and to subsequent asset-allocation decisions. They are particularly important to investment strategies that aim to mitigate climate-related risk or exploit climate opportunity by focusing on these highly impacted names.

Company-level insights derived from scenario analysis can and should be aggregated into a portfolio-level view of exposures, ensuring that the overall portfolio is climate-resilient and that risks are being managed appropriately. It is important for the manager to consider the interactions and cumulative impacts of climate exposures under different scenario pathways so that as policy changes are announced and as technological developments occur, the manager understands how the portfolio is likely to respond. If necessary, appropriate adjustments can then be made within the portfolio (in terms of regional, sectoral and company exposures) to respond early to important developments and to ensure that the portfolio is a net beneficiary of these changes.

Considering and managing exposures at the portfolio level also enables the manager to selectively retain exposure to certain companies, sectors and regions that may have greater vulnerability to climate-related impacts or be less able to abate them, but which nevertheless present significant investment opportunities – provided this is offset elsewhere in the portfolio – and that the aggregate exposures are appropriately aligned to deliver the requisite decarbonisation and climate alignment. Management of these risks at portfolio level also better enables climate-related risks to be integrated into the broader investment portfolio construction process taking into account other factors such as asset liability management for insurers.

The concept of a climate 'budget' and overall trajectory for a fund (aligned to a desired climate outcome) is a helpful one because it allows a manager to take attractive investment opportunities that may present themselves across sectors and regions but to manage the overall exposure at the portfolio level to ensure that risks are well managed, and the desired climate objective is achieved. Indeed, there is a space for client outcomes that are specifically targeted towards particular climate outcomes, as well as those that aim to help finance and deliver the climate transition in a more general and less measured way. The climate-scenario work described in this use case can allow us to see not only a portfolio's current footprint and climate value at risk, but also to take a forward-looking view of a portfolio's emissions and intensity under different scenario pathways and to adjust these to target particular climate objectives.

One good example of climate-focused strategy is the climate-tilted benchmark. Most investors gain exposure to equities and other asset classes using standard benchmarks like MSCI World or FTSE 100. These indices may either be tracked by passive index funds or used as the benchmark for active managers. To manage climate-related risk or move to Net Zero portfolios, one important method that investors are exploring is to replace these benchmarks with low-carbon, high-climate-solution alternatives. When making this switch, investors generally aim to ensure that climate-tilted benchmarks demonstrate similar financial characteristics to their standard equivalents.

To do this, users can employ portfolio-optimisation tools that use historical security-level returns and correlation data to generate portfolios with low deviation in returns, or 'tracking error', relative to the standard index, but with substantial improvements to carbon performance. We have found that it is possible to achieve large tilts away from carbon-intensive companies towards climate-transition leaders and climate solutions while maintaining very similar sector exposures, with a similar tracking error to the standard benchmark.

The key message is that climate-enhanced benchmarks can be expected to outperform standard equivalents in the mean climate scenario and across most of the climate-probability distribution. This helps reassure investment committees that a switch to these benchmarks is currently sensible from a financial perspective. This result may not always hold true – as indicated above, if governments fail to implement their current commitments, or if there is a ‘green bubble’ pushing prices of clean-technology stocks or tech stocks that are over-weighted in low-carbon indices far above fair value. If this were to occur, investors might have to adjust climate-aligned benchmarks to reduce their climate ambition or to focus tilts on the remaining positive-return opportunities.

# 7. Future developments

Climate scenario analysis is new for many firms, requiring new skills, data, methodologies, and time to build the relevant infrastructure. Regulators too are learning and expectations from a range of stakeholders are rising.

This chapter builds substantially on the CFRF Scenario Analysis chapter published in 2020, reflecting that climate scenario analysis remains a fast-evolving discipline. New scenarios, scenario providers and advice will continue to emerge. It is therefore important for firms to keep abreast of the latest developments.

We recognise that firms have more work to do to fully establish climate scenario analysis practices. Firms conducting climate scenario analysis for the first time are advised to keep the scenarios and analysis simple at the start and enhance it over time as they gain knowledge and experience as well as build the required infrastructure.

This chapter provides a useful reference point for firms looking to develop their climate scenario analysis, by identifying the range of practices used by other firms. We encourage firms to consider this document as a reference when developing their own internal practices.

It has explained how firms can use external reference scenarios, in particular those developed by the NGFS, to assess the financial impact of climate-related risks on their strategy and business decisions, for example, under an abrupt low-carbon transition or high physical risk world. It also has explored how firms can assess the impact that their business activities (lending, investments and underwriting) have on the climate – the issue of portfolio alignment – as well as the use of scenario analysis for optimal portfolio design.

Looking ahead, we are developing an online climate scenario analysis narrative tool to support smaller firms. The idea of the tool is that firms would input some basic information regarding their business activities, products, or risks into the tool. The tool would then output a narrative description of climate risks and opportunities for a selected NGFS scenario (i.e. Orderly, Disorderly, or Hot House World). This tool is currently planned to be launched in the first quarter of 2022 and will be hosted by the UK Centre for Greening Finance and Investment (CGFI).

The working group has also identified the following areas for potential future work:

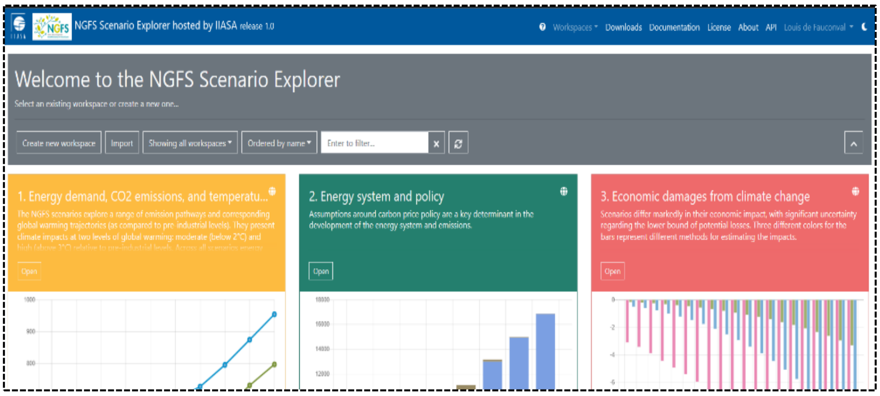
1. Assessment of the pros and cons of using different reference scenarios and how they compare and relate to each other e.g. NGFS, CBES and IEA.
2. In collaboration with other stakeholders consider how to build on CBES exercise and the lessons learned from it.
3. Provide guidance on how to conduct sensitivity analysis for key variables and assumptions underpinning scenarios.
4. Identification of other potential risk transmission channels that have not been covered in this report e.g. reputational and litigation risk.
5. Consider how to take into account adaptation in climate assessment and what alignment means with respect to climate adaptation.

# Annex 1: Additional detail on NGFS scenarios

More information on the NGFS scenarios can be found on the NGFS scenarios portal: https://www.ngfs.net/ngfs-scenarios-portal/

Detailed NGFS scenario parameters are hosted by the IIASA (link: https://data.ene.iiasa.ac.at/ngfs/#/workspaces) where Excel files of variables can be downloaded.

***Figure A1: Screenshot of IIASA Database***



## *Figure A2: Overview of NGFS scenario components for Energy Sector*

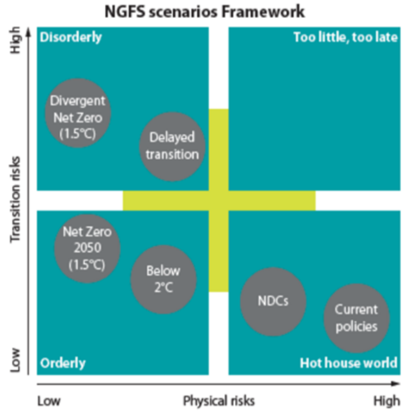
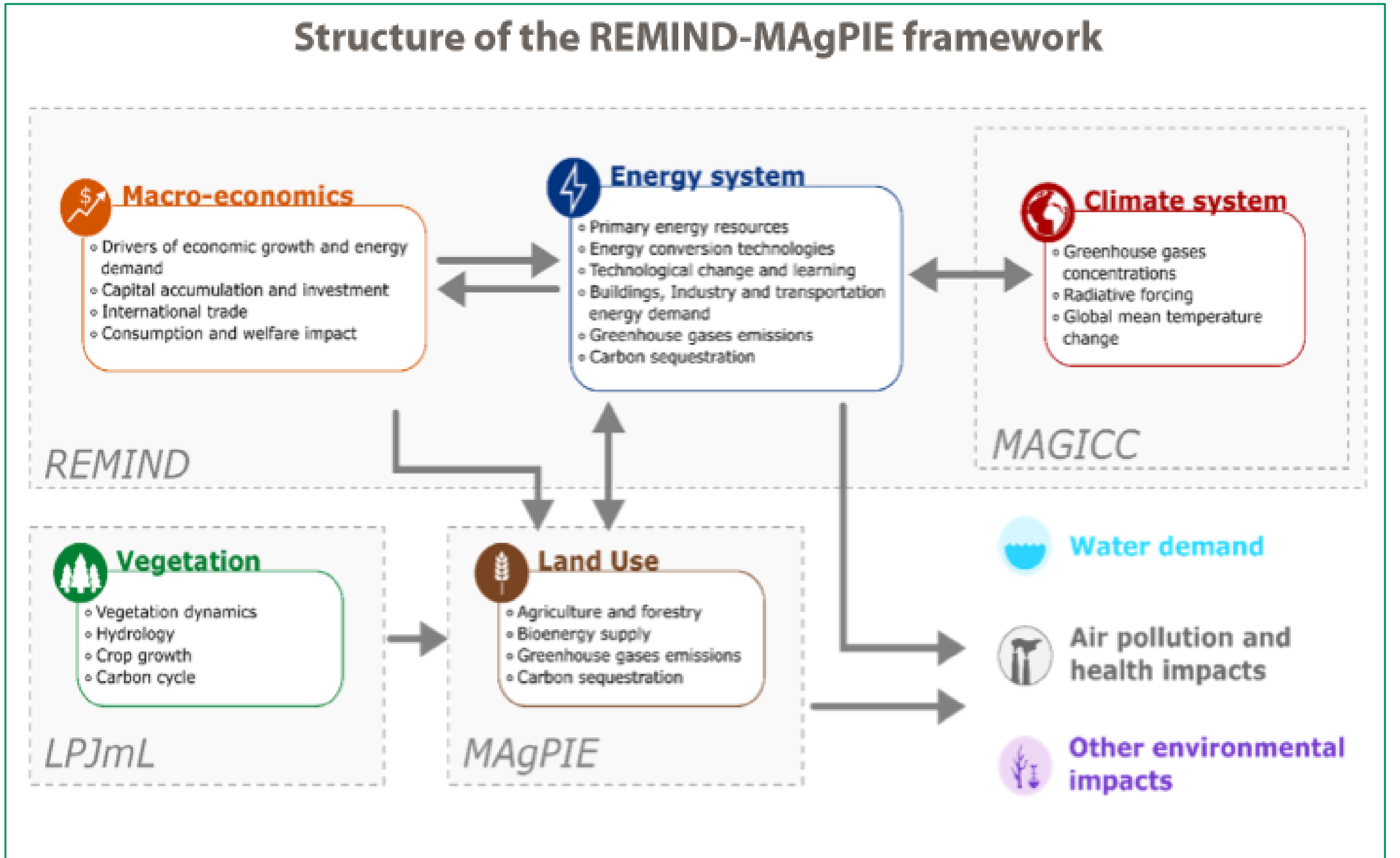
| ENERGY TRANSITION SCENARIOS - NGFS JUNE 2021 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1 Socio-economic pathway (SSP)** | **3 Integrated Assessment Models (IAMs) describe and assess the interactions btw human activities and environmental processes** | | | **3 reference NGFS scenarios** | | | **NiGEM** |
| **SSP2 "Middle-of-the-road"** | **GCAM (Global Change Assessment Model)** | **"MESSAGEix-GLOBIOM" developped by IIASA-IAM** | **REMIND-MAgPIE** | **3 quadrants categories** | **6 scenarios x 3 IAMs** | | **country outputs** |
| **Projections of**<br>**- GDP in PPP**<br>**- population**<br>**- urbanisation** | **- macroeconomic**<br>**- agriculture & land-use**<br>**- energy**<br>**- water**<br>**- climate systems** | **- energy (MESSAGE**, Model for Energy Supply Strategy Alternatives and their General Environmental impacts**)**<br>**- land-use (GLOBIOM**, GLobal BIOsphere Management**)**<br>**- air pollution & (GHG GAINS**, Greenhouse gas–Air pollution INteractions and Synergies**)**<br>**- macroeconomic (MACRO)**<br>**- climate (MAGGIC**, Model for | **- energy (REMIND)**<br>**- land-use (MAgPIE)**<br>**- water (LPJmL)**<br>**- air-pollution & health**<br>**- economy (REMIND)**<br>**- climate systems (MAGICC)** | | | | **GDP, Consumption, investment, government expenditure, unemployment rate, interest rates, RE prices, etc.** |
| | | | | | | | |
| 5 SSPs are translated into 24 Integrated Assessment Models (IAMs), i.e.baseline scenarios of energy use and emissions. The marker IAM of SSP2 is the MESSAGE.<br><br>Population peaking between 2070 and 2080 around 9.5 billion | <br>*Figure 1 Overview of the NGFS scenarios. Scenarios are indicated with bubbles and positioned according to their transition and physical risks.* | | | **Hot house world**: limited action leads to significant global warming and, as a result, strongly increased exposure to physical risks | Current policies | GCAM<br>MESSAGEix-GLOBIOM<br>REMIND-MAgPIE | |
| | | | | | Nationally determined contributions (NDCs) | GCAM<br>MESSAGEix-GLOBIOM<br>REMIND-MAgPIE | |
| | | | | **Orderly**:<br>early, ambitious action to a net zero CO2 emissions economy | Below 2°C | GCAM<br>MESSAGEix-GLOBIOM<br>REMIND-MAgPIE | |
| | | | | | Net Zero Emissions 2050 1.5°C | GCAM<br>MESSAGEix-GLOBIOM<br>REMIND-MAgPIE | |
| | | | | **Disorderly**:<br>action that is late, disruptive, sudden and / or unanticipated | Delayed transition 2°C | GCAM<br>MESSAGEix-GLOBIOM<br>REMIND-MAgPIE | |
| | | | | | Divergent Net Zero policies 1.5°C | GCAM<br>MESSAGEix-GLOBIOM<br>REMIND-MAgPIE | |

*Figure A3: Structure of the REMIND-MAgPIE Framework*




Source: NGFS Climate Scenarios Technical Documentation.

# Annex 2: Resources


- Aberdeen Standard Investments (2021), *Climate Scenario Analysis: A Rigorous Framework for Managing Climate Financial Risks and Opportunities, link*
- ACPR (2021), *Scenarios and main assumptions of the ACPR pilot climate exercise*, link
- ACT (undated), *ACT Assessment Methodologies,* link
- Bankers for NetZero (undated), *Bankers for Net Zero, Volans and UK banks,* link
- CA100+ (undated), *Climate Action 100+,* link
- CarbonBrief (2018), *Explainer: How 'Shared Socioeconomic Pathways' explore future climate change*', link
- Climate Action Tracker (2021), *Global Update: Climate Summit Momentum,* link
- Climate Bonds Initiative (undated), *Financing credible transitions*, link
- Climate Transition Pathways (undated), Introducing Climate Transition Pathways, link
- CPI (2019), *Understanding the impact of a low-carbon transition on South Africa,* link
- GFANZ (undated), *Cop26 and the Glasgow Financial Alliance for Net Zero,* link
- ICMA (2020), *Climate Transition Finance Handbook,* link
- IEA (2021), *Net Zero by 2050,* link
- ING (2020), *2020 ING Terra Progress Report,* link
- ING (2021), *2021 ING Climate Report*, link
- ING (undated), *Terra Approach,* link
- Institut Louis Bachelier et al. (2020), *The Alignment Cookbook - A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low-carbon Trajectories or Temperature Goal,* link
- *IPCC (2021), Sixth Assessment Report*, link
- McKinsey (2020), *Climate risk and response: Physical hazards and socioeconomic impacts,* link
- NGFS (2021), *Climate Scenarios Database – Technical Documentation V2.1*, link
- NGFS (2020), *Climate scenarios for central banks and supervisors*, link
- NGFS (2019), *Macroeconomic and financial stability, Implications of climate change*, link
- PCAF (undated), *Portfolio Carbon Accounting Framework,* link
- Portfolio Alignment Team (2020), Measuring Portfolio Alignment, link
- Say on Climate (undated), *Shareholder voting on climate transition action plans,* link
- SBTI (undated), *Business ambition for 1.5°C,* link
- TCFD (2021), *Measuring Portfolio Alignment: Technical Supplement*, link
- TPI (2019), *Methodology and indicators report*, link
- UNEP FI (undated), *Net Zero asset managers initiative,* link
- UNEP FI (undated), *Net Zero asset owner alliance*, link
- UNEP FI (undated), *Net Zero banking alliance,* link
- UNEP FI (undated), *Net Zero insurance alliance,* link
- UNFCCC (undated), *Race to zero campaign,* link