CLIMATE FINANCIAL RISK FORUM

CLIMATE FINANCIAL RISK FORUM GUIDE 2023

# SCENARIO ANALYSIS GUIDE FOR ASSET MANAGERS

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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. The document aims to promote understanding, consistency, and comparability by providing guidance on how to use scenario analysis to assess financial impact and inform strategy/business decisions.

This CFRF guide has been written by industry, for industry. The recommendations in this guide do not constitute financial or other professional advice and should not be relied upon as such. The PRA and FCA have convened and facilitated CFRF discussions but do not accept liability for the views expressed in this guide which do not necessarily represent the view of the regulators and in any case do not constitute regulatory guidance.

Any references to external organizations (e.g. case studies or examples) should not be interpreted as endorsement by CFRF and are only for case study purposes.

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# Acknowledgements

This paper has been written by the Asset Management sub-group of the Climate Financial Risk Forum (CFRF) Scenario Analysis Working Group, which includes asset managers, banks, insurers and service providers to the financial industry.

It is largely written by practitioners, for practitioners and is intended to support asset managers in developing their scenario analysis to manage climate risk and prepare for climate action. It outlines the current state, and possible future direction for development, of scenario analysis, as used by and applied to asset managers.

The content in this paper is aimed at asset managers of all sizes but may be of interest to other financial institutions – particularly those that use scenario analysis as a tool to assess future risks.

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# Introduction

## Purpose

Climate change could lead to different climate-related risks, including transition and physical risks[1]. Transition risk relates to the inherent risk from changing strategies, policies or otherwise, as society and the economy attempts to align decarbonisation to limit global warming as per the Paris Agreement. Physical risk relates to the impact arising from changes to weather and climatic conditions. Indirect impacts, involving the subsequent changes to socioeconomic outcomes due to the realisation of a physical risk, could also arise, impacting both asset managers themselves along with valuations of the assets they hold.

Physical risks can be categorised as acute or chronic risks. Acute risks arise from a vulnerability and exposure to event-driven change such as an increased severity or frequency of extreme weather events, e.g. floods, droughts etc. Chronic risks, on the other hand, arise from the long-term shifts in climate patterns (e.g. increasing average temperatures or sea level rise).

Scenario analysis is increasingly used by asset managers, and the wider investment community, as a tool to inform decision making, strategy setting, risk management; as well as to develop an approach to disclosure of the climate-related risks and opportunities.

This paper aims to provide the latest thinking, as scenario analysis capability continues to mature across the asset management industry, expanding upon the future areas of focus identified in the CFRF Scenario Analysis 2021 publication.

## Executive Summary

The chapter is structured around the following sections:

**Section 1** sets out the wider context, roles and responsibilities and recent developments concerning the use of scenario analysis by asset managers. It includes sub-sections on:

| Sub-section | Objective | Questions addressed |
|---|---|---|
| Business processes that scenario analysis can inform | Show how climate scenario analysis may be most useful for an asset manager. | A non-exhaustive list of relevant processes (strategy, risk, investment teams, engagement, technology development, regulatory/group/client reporting) and how climate scenario analysis might inform these processes. |
| An illustrative guide to model selection | Provide an end-to-end view from initiation of model selection through to the dissemination of outputs. | Choice of model and scenarios, applicability across asset classes, appropriateness of inputs, and the use of outputs. |

It then goes on to provide some illustrative case studies before expanding upon foreseeable next steps. The following table highlights the case studies covered by this chapter and how these could be used by asset managers.

[1] These were described in the Prudential Regulation Authority (PRA) 2015 report "The impact of climate change on the UK insurance sector"

| Case Study | How these could be used |
|---|---|
| Case Study 1: *Aviva*<br><br>Assessing Sovereigns climate-related risk and integration in business processes | Measuring sovereign holdings' exposure to physical risk using the University of Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index. |
| Case Study 2: *M&G*<br><br>Assessing Real Asset Risk under 2°C and 4°C scenarios | Physical risk scenario screening at a high level on circa 900 real estate units followed by a deep dive on the higher risk assets on a granular, site-specific basis. |
| Case Study 3: *Fidelity*<br><br>Portfolio Alignment using Scenario Analysis | Using carbon intensity trajectories and thermal coal phase out timelines to baseline the fossil fuel transition plans of corporates. Using the analysis to seek corporate transition plans aligned to 1.5°C through engagement activities and following that whether to support 'say on climate' votes. |
| Case Study 4: *USS*<br><br>Integrating scenario analysis into investments | Modelling carbon price trajectory scenarios by integrating it into Discounted Cash Flow analysis, incorporating future emission reduction plans and feeding it into the ESG score with the purpose of improving investment decision making. |
| Case Study 5: *Invesco*<br><br>Climate aware Capital Market Assumptions | Constructing Climate aware Capital Market assumptions by combining the top-down NGFS scenarios and the bottom-up security level scenario analysis. By better understanding how climate may impact the macro environment (e.g. inflation and growth) and different asset classes (aggregating bottom-up analysis), one can construct a climate aware strategic asset allocation model. |
| Case Study 6: *Aberdeen*<br><br>Incorporation of disorganised scenarios into its climate scenario platform | As transition is driven by political and economic factors, it is highly unlikely to be uniform across regions nor uniquely driven by technology as depicted in Integrated Assessment Models (IAMs). The implications on the investment book can be evaluated by constructing a probability-weighted custom scenario (leveraging a number of existing scenarios - e.g. NGFS, IEA, etc.) and selecting individual aspects of regional/sectoral IAMs to combine into one. This is then used to improve assessment of the risks and opportunities across an Asset Manager's AUM and aid investment decision making. |

**Section 2** outlines the nature and content of the current climate reference scenarios produced by official-sector financial authorities, including the Network for Greening the Financial System (NGFS) and other central banks. It outlines respects in which such scenarios could be extended, to capture other ways in which climate transition might have negative implications on financial stability. This section also describes the way in which such scenarios could be developed in the future.

**Section 3** explores how climate adaptation is – and should in the future be – considered within scenario analysis. It explores the current level of its inclusion within scenarios and the difficulties in achieving the level of granularity needed within most asset classes for asset managers. The section outlines the ways in which both physical risks and adaptation may impact entities; how cost-benefit analysis could be used and how asset managers can assess both the opportunities within adaptation and counterparties' adaptation planning.

# 1. Embedding climate scenario analysis

Developing climate scenario analysis is a valuable step in improving asset managers' understanding of their exposure to climate-related risks. Early iterations of scenario analysis have focused on reporting results across scenarios; and to unlock its true value asset managers are embedding scenario analysis across their business. Fulfilling firms' wider climate responsibility necessitates a significant investment to embed climate-related risks and opportunities across their business, as well as developing internal capabilities to problem solve along the way.

## Context

The Taskforce on Climate-related Financial Disclosures (TCFD) has recommended scenario analysis to be used as a tool to enhance critical strategic thinking by firms and challenge conventional wisdom about the future. In a world of uncertainty, scenarios are intended to explore alternatives that may significantly alter the basis for "business-as-usual" assumptions.

In April 2019, the PRA published the Supervisory Statement SS3/19 "Enhancing banks' and insurers' approaches to managing the financial risks from climate change". This Statement requires firms to embed the consideration of financial risks from climate change in their governance arrangements and risk management practice; use (long-term) scenario analysis to inform strategy setting and risk assessment and identification; as well as develop an approach to disclosure of these risks and opportunities.

In June 2021, The Department for Work and Pensions (DWP) published requirements involving scenario analysis for UK pension funds to improve both the quality of governance and the level of action trustees must take in identifying, assessing and managing climate risk. As clients of asset managers, often they are expected to conduct these analyses and be conversant with model outputs and their drawbacks.

In response to the regulatory requirements, and through the Bank of England's Climate Biennial Exploratory Scenario (CBES) exercise, larger firms (with captive asset managers) have developed climate modelling capabilities and invested in improving their TCFD disclosures. Asset managers have focused on providing a range of metrics and targets described in a way that the public can engage with, including climate-related risk according to IEA or NGFS scenarios. To better understand and explain how the key climate-related risk drivers impact counterparties, 'bottom-up' climate models have been favoured. These models provide more granular output - e.g. at issuer or security level - broken down by climate-related risk driver and offer greater transparency across stages of transformation and calculation. The downside is that such models are more complex to run. For example, those involved in the CBES exercise relied on a small number of third-party models to conduct the bottom-up modelling (Results of the 2021 CBES | Bank of England) which reflects the nascent status of the solutions being developed. To unlock further value from scenario analysis, better clarity is sought on not just what model outputs are, but how and why such an output is arrived at.

Firm-wide business strategies with respect to climate have evolved rapidly in the last three years. Increasingly firms are making commitments by joining initiatives such as the Net Zero Asset Managers Initiative (NZAMi), Science Based Targets Initiative (SBTi), and Glasgow Financial Alliance for Net Zero (GFANZ) as well as being members of the Institutional Investor Group on Climate Change (IIGCC) and the United Nations Principles for Responsible Investment. Many are now committed to not just reducing investment portfolio emissions, but have made additional commitments, such as developing thermal coal and/or other fossil fuel exclusion policies. The IIGCC have developed a Net Zero Investment Framework for asset managers and asset owners that recognises they have a range of levers at their disposal as well as recommending actions they should take to assess and align their portfolios towards net zero. When developed into toolsets, these can enable a climate assessment to be performed on a fund range, as well as guide future enhancements. For example, by incorporating a focus on climate transition and solutions targets and exposure as de facto in new product launches.

An asset manager can tilt their client investment book by developing climate-focused product ranges (e.g. climate solutions, climate transition funds, etc.) as well as evolving their existing product range to successfully integrate climate considerations into investment decision making process, and in so doing serve to improve opportunities and reduce downside risk (to counterfactual), and help meet firm level commitments (NZAMi, SBTi). Some entities have developed these levers into firm-level targets, for example by setting future targets for increasing investments in climate solutions. Many have also set exclusion or transition plans for the material emissions, and risk, of thermal coal exposure.

Scenario modelling can help strategise the timing of such future actions through the climate transition horizon. For example, future governmental policy could be explored with custom scenario modelling, such as examining the impacts of banning of Internal Combustion Engines (ICE) upon the auto sector in 2030 (and its impact on aggregate oil demand) and how risk exposure could be understood and mitigated.

## Roles and responsibilities

Asset manager climate programmes have been driven by the rise of climate champions within firms (e.g. CEOs, Heads of Sustainability, Chief Risk Officers) complemented by regulatory demands, especially those of clients. Such arrangements have originated as a response to available skilled resources and bandwidth across the organisation. Both operational models can, and have, led to strong and rapid development of capabilities over recent years.

For some asset managers, the ownership resides with the Sustainability team who are co-responsible for the asset manager's investment book transition plan with investment teams. Locating responsibility here provides the added advantage to further interrogate and integrate modelling outputs into investment processes and is collocated with Stewardship or Governance activities. Engaging investees on their material climate-related risks to mitigate and adapt to climate change (improve their plans or execution) is a key expectation of a responsible asset manager. Furthermore, the Sustainability team are typically responsible for responding to client requests for scenario modelling outputs. This rapid increase in client requests for detailed climate disclosures (including scenario analysis) has substantiated investment in internal climate capability and knowledge and is increasingly becoming a commercial necessity which can help win and retain business.

There are some advantages to locating ownership in the Risk team. Climate scenario analysis value at risk outputs naturally lend themselves to such a function and in setting risk appetite for the organisation and incorporating these into first and second lines. This function is also responsible for regulatory exercises and responses as well as keeping a watchful eye on new developments and requirements that the Sustainability team do not typically do on a day-to-day basis.

For asset managers who have an internal Asset Owner and/or Asset Owner and listed Plc, it is optimal to operate one common model.[2] Whilst either location of responsibility can advance integration on differing aspects, full integration requires clarity of collaboration between: Risk; Sustainability; Investment and Stewardship activities. Regardless of model ownership, Sustainability and Board committees need regular reporting updates.

## Business processes that scenario analysis can inform

When considering how climate scenario analysis may be most useful for an organisation, it is helpful to start with a universe of processes to help inform decision making. The table below sets out a non-exhaustive list of relevant processes for an asset manager and how climate scenario analysis might inform these processes.[3] References below to 'model' mean a model chosen to analyse physical and

[2] An agreed common modelling approach is clearly desirable, whilst it may not have a single model to cover a multitude of public and private asset classes.

[3] Climate scenario analysis is more than the modelled outputs, the learnings from model construction and transformation can also be relevant for informing processes within the organisation. The 'model' refers to the organisation's chosen third-party model.

transition risks of an investment and when aggregated, portfolio(s) of investments.

| Processes to consider | Relevance of climate scenario analysis outputs |
|---|---|
| **Investment** | • Build understanding of climate budget/pathways and key mechanisms of action and associated pricing (e.g. evolution of emissions, price of $CO_2e$, energy mix changes).<br>• Build understanding of how climate scenarios could affect the financials of investees, and flow through into valuation or probability of default of the asset.<br>• Climate scenario analysis should be complemented with temperature ratings at the investee level.<br>• Assess materiality of impact and rankings across sectors and regions.<br>• Understand the key assumptions and associated weaknesses and limitations of the underlying modelling of climate risk. |
| **Portfolio Management** | • Support the heat mapping of a portfolio, identifying areas of further challenge, and investigation.<br>• Support decision making through selection of best in class or tilting towards lesser risk where expected financial returns are equal or better.<br>• Support corporate engagement where there are material risks, targeting improvements of investee climate transition mitigation and adaptation plans in collaboration with research and Stewardship functions. |
| **Strategic Asset Allocation** | • Support decision making within multi asset product lines and due consideration of the climate-related risk (or beta) across asset classes.<br>• Assist in assessing events, such as shock climate policies and/or energy crises and defining climate Capital Market Assumptions. |
| **Stewardship/ Engagement** | • Support engagement on corporate vulnerability, strategy, and capital allocation. Outputs can be combined with firm-wide climate emissions rankings to drive prioritization across largest material group exposures in a 'hot list' approach, incorporating both the largest emitters and their associated climate-related risk. As such, combining both the largest mitigation exposures in the transition to zero and the largest climate impacts on the investment book. This is otherwise referred to as inside out and outside in, or double materiality.<br>• Support the follow through into voting policies where engagement is not progressing appropriately. This is perhaps the greatest agent of change to wider society and the economy from within an asset manager, alongside the redirection of the flow of new capital deployment to finance climate solutions and credible transition plans. |
| **ESG tooling and quarterly review process** | • Asset managers have developed their own internal climate ratings and tools. Integration of climate scenario modelling results into desktop toolsets adds greater depth of understanding to fund-level ESG reviews carried out by Sustainability teams. |
| **Risk Management and Risk Appetite Frameworks** | • Output of results into organizational materiality. Outlining the exposure to aggregated risk bets across multiple funds as compared to benchmark risk.<br>• Ensure climate-related risks are monitored and are within appetite. |
| **Product design, launch and strategic review** | • Input into the firm-wide strategic review of existing product range and future direction in combination with e.g., IIGCC's Net Zero Investment Framework.[4] Action can include increasing the fund range, targeting climate opportunities (climate solutions) and transition funds (seeking to minimize negative effects of orderly and disorderly transitions). |

[4] The Institutional Investor Group on Climate Change guide to the Net Zero Investment Framework.

| Processes to consider | Relevance of climate scenario analysis outputs |
|---|---|
| **Reporting** | • Satisfy TCFD disclosures as well as institutional and regulatory client reporting needs such as those subject to the Department of Work and Pensions requirements, ad hoc climate-specific client requests, and supporting stress tests- e.g. CBES. • Regular internal reporting into Sustainability and Board committees. |
| **ESG Policies** | • Support evidencing thematic risk related to a transitional aspect of climate such as thermal coal, Tars sands, Arctic drilling, and shale gas. Timing or biting points along the transition could be used to develop firm-wide thinking with respect to tactical and timely approaches depending upon the likely evolution of policy, alongside a carbon budget or temperature alignment. |
| **Sustainability and transition plans of asset manager** | • An asset manager's climate transition plan will also be influenced by outputs from its scenario analysis and improvements to it over time, because climate scenario modelling has an increasing role to play in supporting clients and their transition planning. |

## An illustrative guide to selection, development and integration of climate models

A useful starting reference is the previously published CFRF scenario analysis guide. The objective of the process below is to provide an end-to-end initiation of model selection through to the dissemination of outputs for the purposes of integrating climate modelling into a fundamental bottom-up research-based investment process.

### 1. Choice of model provider

A Request for Proposal, containing a list of requirements and questions for suppliers, is typically launched to providers of bottom-up scenario analysis, examining:

- Available market providers[5]
- Credibility of the supplier
- Transparency of model and its construct (strengths and weaknesses)
- The extent of internal resources required to run the model
- The certainty of being able to complete models runs for deadlines
- The budget cost
- Associated licence requirements
- Credibility of the roadmap to include asset classes in the future that do not have solutions today
- Scenarios on offer (including NGFS, RCP, IEA, etc.)

Comfort on the model's development to meet future requirements and reflect wider climate science and available scenarios is likely to be a key long-term consideration as it is unlikely asset managers will change model providers unnecessarily. Asset managers will require model advancement and consistency for the purposes of ongoing comparability in disclosures.

CBES participants overwhelmingly relied on a concentrated number of third-party providers (Bank of England - CBES). It is likely that confidence of delivery to timescales was a deciding factor. The availability of ancillary consultancy services was also a likely key decision factor (GARP Survey on scenario analysis), as they supported firms to gain knowledge and build internal capabilities. The combination of these two factors explains why there were only a few competitive options available.

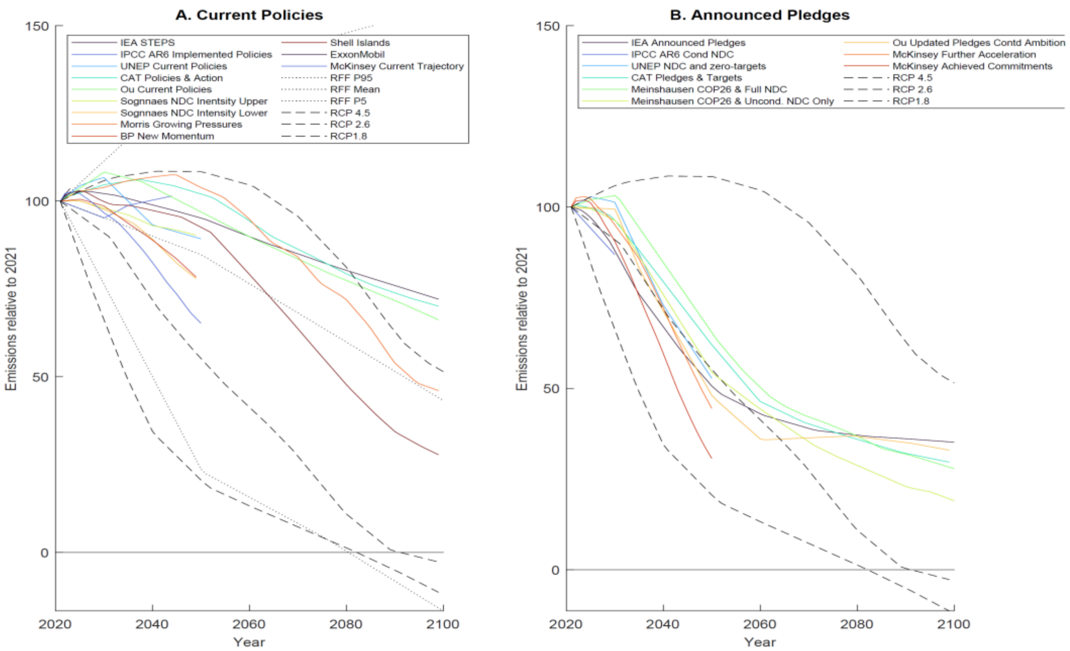
[5] For example, see the CFRF Product Providers Database. A long list of providers is also contained in this resource provided by the UNEPFI.

## 2. The choice of scenario

When participating in a regulatory exercise the scenario is typically pre-set (e.g., NGFS-based scenarios). However, with reporting and disclosure, asset managers can choose to explore scenarios focussing on orderly or disorderly transitions and use reference scenarios from the existing suite of NGFS or IEA scenarios as a starting point. These are typically available 'off the shelf'. They serve the purpose of being able to illustrate the requisite climate pathway and can help challenge the conventional wisdom. A 'hot house' scenario is also widely used today, reflecting a ~4˚C warming by year 2100. It has highlighted the imperative to prevent or mitigate climate change rather than respond once its effects are much greater.

Governmental commitments to net zero targets across the world's largest emitters have improved but more credible transition plans are still needed. Currently scenarios where emissions are significantly more than those in current policy scenarios and significantly below current pledge scenarios (i.e. exceeding current pledges to cut emissions by some way) appear to be relatively unlikely[6].

**Figure 1: Emissions relative to 2021 of total greenhouse gas emissions or CO2 emissions in Current Policy scenarios (A) and Announced Pledge scenarios (B). The dotted lines are expert estimates which include future policy changes (RFF). As a benchmark, dashed lines show three RCP scenarios[7].**




Source: [The unconditional probability distribution of future emissions and temperatures]

So being able to examine a range of scenarios falling between these two emission pathways and quantifying the impacts on investments would aid the integration of climate-related risks into the development of investment strategy and decision making, as too would the development of shorter-term scenarios combining both transition and physical risk. For example, a disorderly scenario where a climate policy tipping point is triggered by an accumulation of climate events across range of perils and geographies.

## 3. Applicability across asset classes

Another key question is whether a model can be deployed across asset classes (breadth), and the associated market value coverage of the asset pool (depth). The CBES exercise required

[6] https://www.lse.ac.uk/granthaminstitute/publication/the-unconditional-probability-distribution-of-future-emissions-and-temperatures/?mc_cid=a3b25d5c5f&mc_eid=c15cf331f4

[7] Further detail on Representative Concentration Pathways (RCPs) can be found in the IPCC overview on Representative Concentration Pathways (RCP).

understanding of the top counterparty exposures, yet TCFD reporting will mean that firms will look to expand the scope of their reporting over time both in terms of breadth and depth. A test exercise would be advisable across equities, corporate debt, sovereigns, and real estate to in order to gain experience and to identify gaps and challenges in the process as well as to obtain preliminary results. These results can be sense checked by sustainability and investment professionals from each asset class to help examine the model strength and weaknesses and comprehend what is required to run the model on a wider scale.

## 4. Inputs

Model owners can face a variety of challenges in obtaining the data inputs that are used or need to be used to run a bottom-up model. For example, this may be because of model licencing constraints, non-disclosure of relevant information by counterparties, or because third-party data providers may not have picked up the necessary information or done so accurately. These can constrain coverage if not considered up front. A key advantage of having access to and/or making the inputs of a model run available is it enables sensitivity analysis to the inputs to be conducted which increases transparency of the model aiding understanding of its limitations and therefore what the outputs of the model can and cannot be used for. It serves to improve integrity and credibility, and in doing so facilitates greater integration into investment decision making. Here are some factors to perform quality analysis on:

| Factors to perform quality analysis on | Proposed actions |
|---|---|
| A corporate does not have reported, estimated or correct emissions on a data provider | Direct enquiry to the counterparty and/or the use of proxy and trend analysis can be helpful. |
| Segmenting the quality of inputs | Grading of outputs by input quality allows for qualification of the outputs. Those that have estimated emissions might be qualified while those that have assured and reported data are less so. |
| The extent climate transition plans of investees can be incorporated into future emissions trajectories of the model | Collecting and assessing climate transition plans of investees. |
| Reported financial data can be distorted by large one offs, especially in the case of Covid years, distorting projections | These need to be identified and flagged for caution. |

Model outputs can be fed back to portfolio management teams to collaborate and challenge current wisdom and facilitate further integration into investment decision making. Dedicated sessions can be enormously productive in disseminating key information such as:

- The extent of emissions reduction required by each sector, across each pathway and their timings.
- The extent of carbon price changes that drive substitution effects.
- The technology assumptions (e.g. proportion of renewable sources needed within the electricity system to hit 1.5°C targets).
- Future energy mix projections (coal, oil, gas, nuclear, etc.).

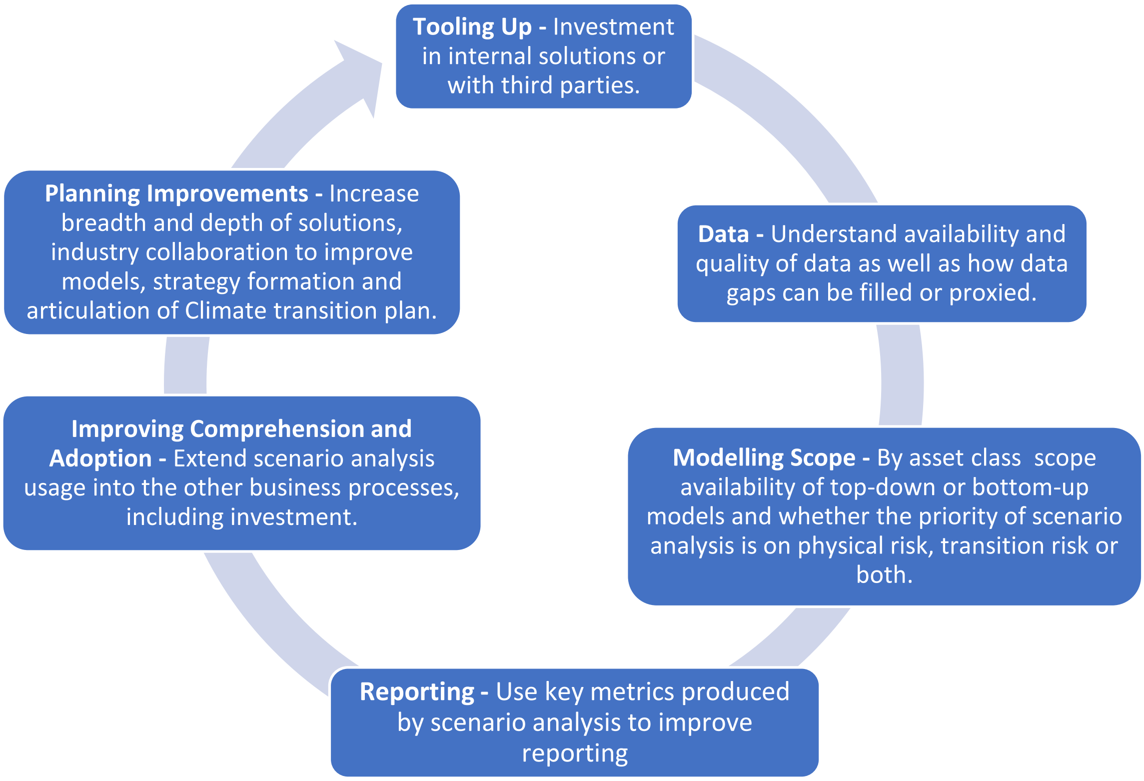
Naturally the challenge to conventional wisdom will focus disproportionately upon the downside outliers in the disorderly transition scenarios. A key aspect of the process is the exchange of insights between functions. On one level, the model owner explaining why the value at risk was arrived at, which particular inputs drove the result, and what might have amplified it (e.g. leverage or cash generation). From the analyst's perspective, spotting missing inputs, climate targets and/or errors in the inputs feed back into the model and process cycle for the following year, as well as dialogue or engagement with the investees. Such a modelling cycle is illustrated in Figure 2.

Institutional clients and their advisors are increasingly requesting climate-related risk outputs for their public and private portfolios. Currently it is incredibly costly and not always possible to run private assets. An interim step might be to use the results from public portfolios to proxy value at risk for some private assets.

The learnings from this process take a step towards addressing some of the Bank of England's key summary learnings from CBES (Bank of England CBES results). The following were flagged: investment in data capabilities; scrutiny of data and projections by third parties; the capture of appropriate and robust data (breadth of inputs including emissions and financial data); and the lack of standardised emissions reporting.

The next steps in the process can leverage elements of this early investment to assist in creating custom scenario run capabilities, and work towards expanding the breadth of scenario analysis into other private asset classes.

**Figure 2: Climate modelling use cycle**

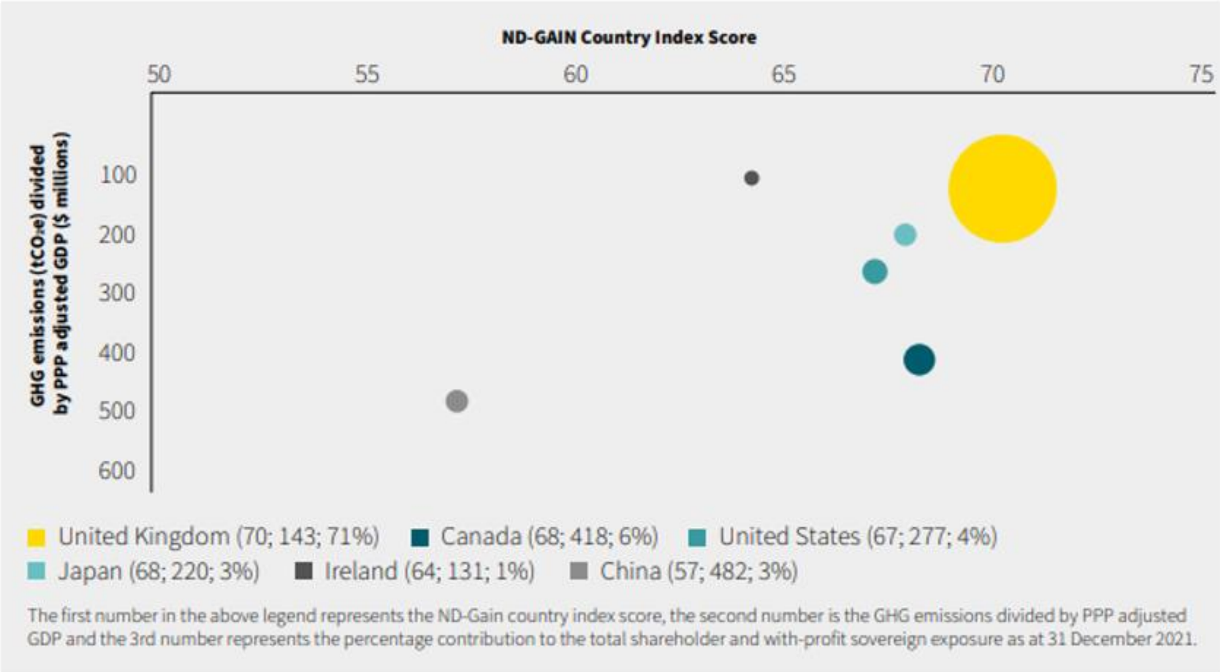



## Case Study 1: Assessing Sovereigns climate-related risk and integration in business processes

Aviva is a long-term investor in sovereign debt across our fixed income portfolio and are particularly focused on improving the sustainability outcomes linked with sovereign debt. Aviva's sovereign strategy is underpinned by our ambition for all countries to commit and meet emission reduction targets, equipping companies, Finance Ministries, Central Banks, and companies with the tools to decarbonise the global economy. At Aviva, we believe it is important to drive an equitable transition, leveraging our influence as a sovereign investor. We use a variety of metrics and tools to manage the potential financial impact of climate-related risks and opportunities on our business, as well as to monitor our alignment with global or national targets on climate change mitigation. We share metrics on a quarterly basis at a Group and business unit level; these metrics are used internally in various processes from monitoring risk appetite to business planning to measuring progress against our external climate plan.

We use the University of Notre Dame Global Adaptation Initiative (ND-GAIN)[8] Country Index to measure our sovereign holdings' exposure to physical risk – the higher the score the better. We also use a sovereign emissions intensity metric (greenhouse gas emissions by PPP-adjusted GDP) to measure countries emission intensities on a purchasing power parity adjusted basis - the lower the score the better. Aviva is predominantly exposed to sovereigns from developed markets. We have no significant exposure to countries highly vulnerable to the physical effects of climate change and our exposure to moderately exposed countries is captured as part of our risk management and monitoring of sovereign risk. We have no material exposure to sovereigns whose credit quality is reliant on oil and gas production. We also monitor our exposure to countries with an ND-GAIN Country Index score of under 50.

**Figure 3: Sovereign holdings exposure to climate-related risks, ND-GAIN country index scores and sovereign emissions intensity for Aviva's top sovereign holdings in shareholder and with profit funds as at 21/12/2021.**




Source: Aviva, ND-GAIN (2019), World Bank, Climate Watch data

We have also incorporated sovereigns in our climate scenario analysis. The following climate-related factors may impact sovereign debt: exposure and vulnerability to climate change; readiness and adaptation; ability to raise money for mitigation and post-disaster repair; ability to raise money via taxation and debt; reliance on foreign aid and support of the International Monetary Fund and other supra-national bodies. The impact on the market value of a security is measured by assessing how a sovereign's rating could change as a result of these factors.

We note that the assessment of sovereign debt is difficult because sovereigns are exposed to climate change via several vectors: government buildings and government-owned infrastructure, cost of emergency relief to areas affected by climate-related disasters, aid and rebuilding costs and the cost of acting as insurer of last resort. With this in mind, the ND-GAIN data has been used to help support expert judgements about the appropriate stresses to apply to different sovereign bonds in our modelling at this stage. We will continue to work internally and with external partners to develop best practice in this area.[9]

[8] The ND-GAIN country index measures a country's vulnerability to the physical effects of climate change and its readiness to adapt to its effects by considering economic, governance and social readiness.
[9] For further information see Aviva's 2021 Climate Financial disclosure.

## Case study 2: Assessing Real Asset Risk under 2°C and 4°C scenarios

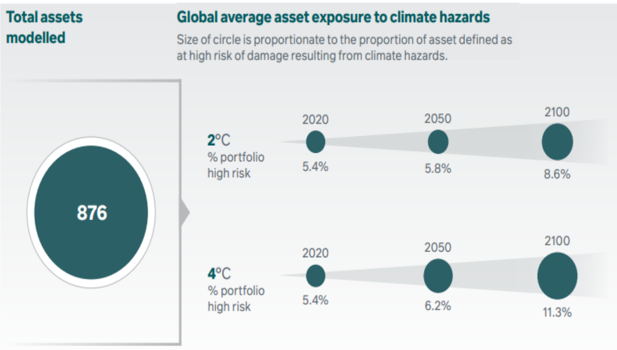
As part of a comprehensive programme to expand the breadth of scenario analysis across its total asset base, M&G initiated a comprehensive programme of model runs across 2 model providers which covered Equities, Corporate and Sovereign debt, and Real estate assets. The real estate results represent 876 distinct assets exploring physical risks, a total of approximately £40 billion by market value. The assets were projected under two climate scenarios broadly aligned to:

- an orderly 2°C scenario or RCP 2.6 and predicts a 1.6°C temperature rise by 2081- 2100, compliant with the Paris Agreement.
- a 4°C scenario or RCP 8.5, which predicts an average temperature change of 4.3°C by 2081-2100, assuming no global response to climate change beyond what has already been committed to.

Under each scenario, assets were rated low (<0.2% value at risk (VaR)), medium (0.2% - 1.0 % VaR) or high (>1% VaR) risk.

The chart below shows the proportion of high-risk assets at select time periods[10] under both scenarios (by number of assets). Under the 4°C scenario, the 11.3% of assets by amount (99 distinct assets) represents approximately 7.9% of the portfolio measured by reinstatement value.[11] The table below sets out the top 10 highest risk assets in the portfolio and the proportion of their VaR.

**Figure 4: Summary Portfolio risk metrics from M&G Real Estate scenario analysis**




| Country | Reinstatement Value (£m) | Value at risk (4°C 2100) | Reinstatement value x VaR |
|---|---|---|---|
| Denmark | 439 | 20.6% | 90 |
| United Kingdom | 126 | 21.1% | 27 |
| United Kingdom | 108 | 21.1% | 23 |
| Sweden | 270 | 5.8% | 16 |
| United Kingdom | 73 | 21.2% | 16 |
| United Kingdom | 73 | 21.1% | 15 |
| Sweden | 1,214 | 0.9% | 11 |
| United Kingdom | 52 | 21.3% | 11 |
| United Kingdom | 44 | 21.2% | 9 |
| United Kingdom | 35 | 21.1% | 7 |

Source: M&G Sustainability report

This list includes both assets exposed to a high amount of risk, and high value assets exposed to a low or medium level of risk. This table shows the risk is concentrated over a small number of assets (since the reinstatement value x VaR measure drops rapidly after the top 10). The riskiness of UK assets are all similar, representing the limited range of physical risks the UK is exposed to. 83.3% of our aggregated climate-related exposure is contained in 5 countries: UK, Denmark, Canada, Sweden, and Japan. We measure the risk for real estate assets at 2100 given the slower emergence of physical risks relative to transition risks.

Whilst our scenario analysis has identified areas of higher risk exposure within our portfolio, our modelling approach accounts only for the current level of national defence mitigations. National defences may be upgraded in the future and, therefore, this approach contains some limitations. Where hot spots have been identified, we will undertake further analysis to evaluate asset specific exposure and climate resilience. Over time, we seek to account for improvements in national defences and climate resilience programmes in our analysis. For example, in 2021 we undertook an analysis of the impact of potential Thames Barrier improvements on the risk exposure of London properties, and over time how we can plan to integrate such analysis into our scenario modelling.[12]

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[10] Time periods of 2020, 2050 and 2100

[11] Reinstatement value is an estimate of the cost to rebuild the property and is data that is readily available as a model input as it is used for insurance purposes.

[12] For further information see M&G's Sustainability Report, pages 46-51,covering other asset classes.

# Case study 3: Portfolio Alignment using Scenario Analysis

Climate stewardship is an integral part of Fidelity's net zero strategy. Whether in one-to-one engagement with our investee companies, in collaboration with other investors or in our proxy voting activities, our net zero and interim decarbonisation targets are contingent on our performance in promoting the adoption and realisation of corporate transition strategies that align to the goals of the Paris Agreement. To ensure the success of this approach, our climate stewardship must be highly informed and, at times, technical. One of the many tools we use to aid us in this process, alongside our proprietary Climate and Sustainability Ratings, is climate scenario analysis. Below, we provide examples of how this has been applied by Fidelity's investment team in recent months.

**Oil & Gas**

Fidelity has long-running engagements with many of the Oil & Gas Majors, and over the last two years we have witnessed a steady increase in the proliferation and ambition of decarbonisation targets. However, one of the greatest challenges we, like many others, face is interpreting how transition strategies compare across peers and whether they are truly aligned to a 1.5°C - or well-below 2°C trajectory.

To inform this process, benchmarking companies both in terms of their current emissions intensity and the future trajectory implied by their reduction targets can be an invaluable tool for cross-comparison. Similarly, comparing these trajectories to models from, for example, the IEA's World Economic Outlook and Net Zero Emissions by 2050 (NZE) reports, contextualises targets and informs our discussion around their ambition.

Such scenario analysis is also an important input into how Fidelity votes on AGM '*say-on-climates*'[13], which often involves engagement both pre- and post-AGM to communicate expectations and set objectives. For example, in a case earlier in 2022, Fidelity supported a management-proposed transition plan in-part due to its targets implying medium and long-term carbon intensity alignment with an IEA Net Zero Emissions trajectory.

Intensity-based scenarios are a useful tool to normalise and compare companies within sectors, particularly, to interpret various emission reduction targets. Nevertheless, to assess how these targets will be implemented and how global climate goals will be achieved in the real world, it pays to look at absolute emissions reductions as well. In a scenario where a company develops a new long-cycle gas project, it may improve emissions intensity, assuming existing energy mix is oil-heavy. But such a project would still be inconsistent with climate guidance that no new natural gas fields are needed in a 1.5°C pathway beyond those already under development[14]. Such analysis is also important to understand other activities such as asset divestments, under which circumstances we would ask companies to re-baseline. Hence, a more holistic assessment is necessary to better understand Paris-alignment.

**Thermal coal**

Fidelity has launched a just transition engagement approach to thermal coal. Consistent with the IEA Net Zero by 2050 scenario, we will gradually phase out portfolio exposure to thermal coal in OECD markets by 2030 and non-OECD markets by 2040.

Our engagement focusses on identifying the systemic drivers behind the continued role of thermal coal in our energy mix and seeks to influence an expedited phase-out of unabated coal throughout our portfolios in a manner consistent with the Paris Agreement. We are targeting the entire value chain, as well as enablers, to address our direct and indirect exposure to thermal coal in a meaningful way and prioritise a phase-out that achieves real world outcomes, including:

- Power generators with greater than 5GW of thermal coal capacity

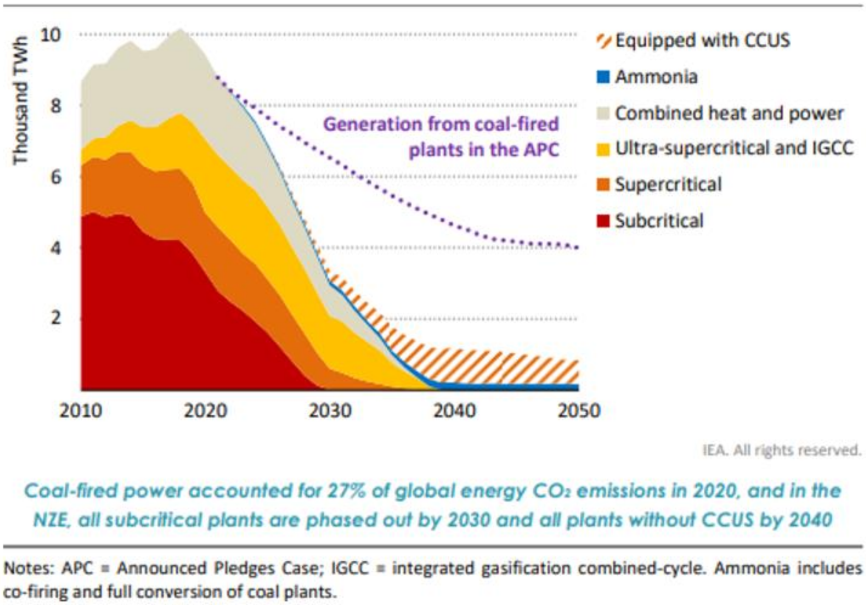
[13] The "Say on Climate"[1] initiative was launched in 2020 to promote board-sponsored resolutions aligned with supporting the transition to net zero. sayonclimate.org

[14] International Energy Agency, net zero by 2050, 2021, Net Zero by 2050 – Analysis - IEA

- Miners producing in excess of 10Mtpa of thermal coal
- All companies with greater than 5% of revenues tied to thermal coal activities

These engagements are timebound and, if companies show no progress after an engagement period not exceeding a pre-determined engagement period and we see no prospect of increasing their transition potential, we will look to divest in-line with our net zero commitment to phase-out coal in OECD by 2030 and globally by 2040.

**Figure 5: Coal fired technology in the IEA NZE scenario**




Source: IEA, 2022

The IEA Net Zero by 2050 scenario is a key piece of our engagement with issuers as it gives us the baseline to evaluate credible transition plans. We are using IEA's forecasts on coal phase-out and have interpolated them into annual coal output reduction steps, both in terms of generation and supply, which has enabled us to have in-depth conversations with our investees about their coal phase-out plans. More importantly, it arms us with clear expectations of which scope of output and emissions we expect to see. With the NZE scenario, we can analyse the ambition required to align with 1.5°C and emission reductions required to get there.

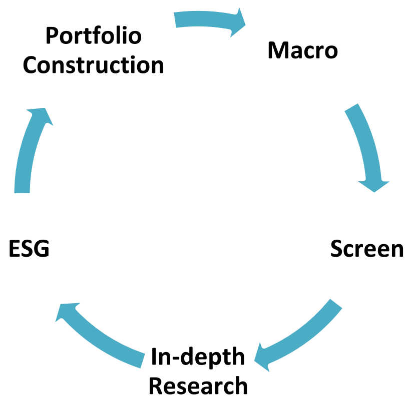
## Case study 4: Integrating carbon price scenarios into discounted cash flow analysis

The Universities Superannuation Scheme (USS) emerging market equity team conduct bottom-up carbon analysis to model how climate-related risks can impact a company's valuation. This carbon analysis is generally focused on transition risk. Introducing carbon prices is a tool to transition the economy to a lower emissions pathway and, as a carbon price can be introduced relatively quickly with clear effects, lends itself to bottom-up scenario analysis in company valuation.

The benefit of carbon analysis is that it can be integrated into existing discounted cash flow models, using carbon intensity data, and so a carbon price can be used to model the impact on a company's valuation. As with any scenario analysis, carbon pricing is not about forecasting the future but more about understanding a range of possible outcomes. The team at USS use a range of different carbon price scenarios based on company meetings, external carbon price scenarios (such as the IEA's Net Zero by 2050 scenarios), market prices and public disclosures such as the internal price of carbon used by a company and disclosed to the CDP (formerly the Carbon Disclosure Project). This exercise may identify significantly different carbon price scenarios, which is helpful as it leads to more interesting analysis and spurs discussions within the team as well as when engaging with the company.

Alongside the carbon price itself, the team builds in an analysis of whether a company will become more or less carbon intensive during the valuation period. This may be driven by a company changing its business mix, investing in research & development, spending more on green capital equipment or altering its energy supplies. They also incorporate carbon allowances (although these are frequently temporary) and their judgement of a company's ability to "pass through" elements of any carbon tax, as they have experienced companies doing so with carbon taxes specifically and taxes in general.

**Figure 6: USS Emerging market equity team carbon analysis process**



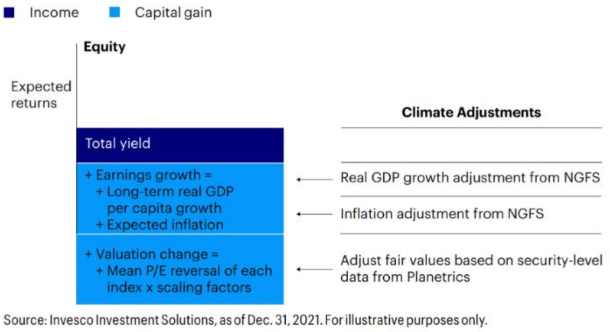

The main output of this analysis is the impact of different carbon price scenarios on the discounted cash flow valuation. This is then fed into an ESG score and assessment, along with other factors such as emission reduction plans and carbon transition. Where possible, the team is also able to factor in physical risks. This is done qualitatively, unlike the standardised, quantitative analysis approach for carbon prices. The ESG risks are built into the team's investment modelling and research to ensure that material issues are integrated into investment decisions. It helps to drive the agenda at meetings with companies and can contribute to the overall investment decision making process.

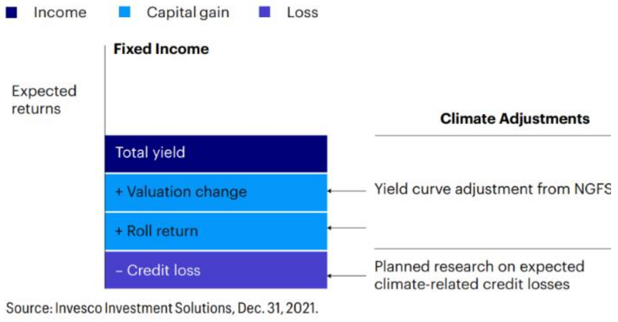
## Case study 5: Climate aware Capital Market Assumptions

Capital Market Assumptions (CMAs) provide long-term estimates for the behaviour of major asset classes globally. The assumptions, which are based on a 10-year investment time horizon, are intended to guide strategic asset allocations. For each selected asset class, Invesco Investment Solutions (IIS) develop assumptions for expected return, standard deviation of return (volatility) and correlation with other asset classes. Recognizing the impact physical and transition risks will have on assets, we have incorporated climate scenario analysis into our CMAs. The transition to net-zero is around a 30-year time horizon that stretches to 2050, but we have designed our climate-aware CMAs to focus on the first part of that transition as that is what investors may experience over the next five to ten years. As we get closer to 2050, the CMAs will take on different stages of the climate scenarios.

We use the NGFS analysis to understand how climate change may affect the macroeconomic environment and its impact on different asset classes. We can also add adjustments to security-level data, based on the analytics provided by Planetrics, part of McKinsey Sustainability. We then make both these climate-related macro adjustments and those made at a security level for the asset class we are looking at: either equities or fixed incomes. Within the three building blocks of our equity CMAs, climate-related adjustments are made to earnings growth and valuation change. For fixed income CMAs, adjustments are made to yield, roll return, and valuation change.

**Figure 7: Climate adjustments made to equity and fixed income CMAs**




***Equities Earnings* growth -** As earnings growth is expected to converge with GDP growth over time, the NGFS data are ideal for understanding long-term projections for GDP under different climate scenarios, both by transition risk and physical risk. In our climate-aware CMAs we are modelling for a 1.5°C scenario. How you make these adjustments to earnings growth is very simple. For instance, if real earnings growth in the US was 2.69%, you would add the combined estimates of physical and transition risks totalling -0.06% to arrive at a climate aware US real earnings growth rate of 2.63%[15].

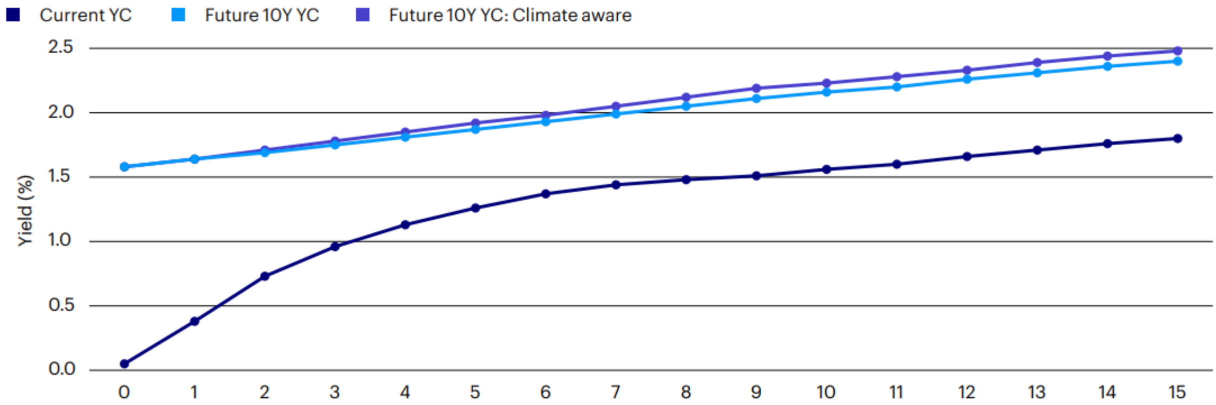
***Equities Inflation risk -*** The type of expected inflation driven by climate change is derived from forecasts on energy prices and demand. The model maps the impact of inflation and energy costs, which it breaks down by energy type. This includes the consumption of coal, oil, gas, and renewable energy. Once calculated, these figures are used to adjust each annual expected inflation rate for the next 10 years and the final average is the climate CMA's inflation adjustment.

***Equities Valuation change -*** The goal here is to adjust the fair values that we have derived for the stocks we cover. These adjustments are based on the analytics provided by Planetrics. The first step is to calculate the impact climate-related risk will have on earnings up until 2050. The model constructs a discount cash flow model based on these projected and adjusted earnings, using the security specific discount rates that they have derived through their financial statement analysis. What is left is a new fair value climate aware valuation for a stock. The next step is to aggregate sector-level adjustments from valuation changes to a regional or index level by re-weighting them to the sector weights of a given universe. The result of combining your climate-aware adjustments for earnings growth, inflation risk and valuation change is your 10-year CMA return. The most significant building block to change is inflation, which is expected to affect the expected equity return on individual stocks by about 1%-2%. This makes sense because climate change is expected to have an inflationary effect through the cost of carbon.

***Fixed income -*** We use NGFS' 10-year rate based on their net-zero 2050 scenario to re-estimate yield, roll yield and valuation change, which alters the shape and slope of the yield curve. For example, for the US, part of the expected curve is shifted upwards and will likely continue to see upward adjustments (see Figure 8), reducing the valuation building block. China's yield curve, however, is shifted downwards, improving valuations.

[15] Climate Aware US Real Earnings Growth = 2.69% - 0.06% = 2.63%

**Figure 8: How the US Yield Curve is transformed by the climate-aware fixed income Credit**




Source: Invesco Investment Solutions, Dec. 31, 2021. Forecasts are not reliable indicators of future performance.

A future enhancement to our climate-aware building blocks will be to estimate the impact of credit losses which could potentially be large due to stranded assets or physical destruction of property.

**Investment decision making**

The great benefit of using climate adjusted CMAs is that they can be used to construct a climate aware strategic asset allocation model. Climate change and the policies that may be implemented could have a large impact on portfolios. Within IIS, our CMAs are updated quarterly and are a key component in our process for developing multi-asset investment solutions. Applying these climate-aware CMAs on a balanced portfolio may result in slightly higher equity weights compared to fixed income given the broad nominal increases to the expected inflation component of the earnings building block. Within equities, European and UK markets are likely to be tilted towards at the expense of the US as they have larger positive adjustments coming from earnings and valuations.

In the future, climate-related adjustments can be made to other asset classes beyond equities and fixed income. For now, our aim in 2022 is to construct green strategic asset allocation models using climate-aware CMAs. Our present research is focused on making climate-related adjustments to the default probabilities of fixed income assets. Furthermore, we would also like to adjust option adjusted spreads that are used to measure credit risk exposure. Should policymakers implement their commitments towards a net-zero 2050 future, our climate-aware CMAs are constructed to capture the impacts in a transparent manner so that investors can account for climate-related risk in their strategic asset allocations.

## Case study 6: Incorporation of disorganised scenarios into its climate scenario platform

Aberdeen's approach to climate-scenario analysis is motivated by the view that a rigorous and transparent methodology is essential for making sound investment decisions, encouraging positive change at the companies in which we invest and achieving robust outcomes for clients. We explicitly take into account the likelihood that the energy transition is disorganised, and is founded on three core beliefs:

a) The political economy and economics of climate-change mitigation does, and will continue to, vary significantly across geographies and sectors.

b) Climate-related policy and low-carbon technology pathways are hard to forecast over long horizons. Accordingly, there are a wide variety of ways in which energy-usage might evolve.

c) Any approach to scenario analysis that assumes uniformity of policy or is based on a single view of technological change, will therefore generate misleading results about the absolute and relative impact of the energy transition across the securities in which we and our clients invest.

As a result, we have developed an approach – with Planetrics – that allows us to design a wide variety of 'bespoke' scenarios that do the following:

- Avoid the implausible assumptions of uniformity that dominate most climate-scenario analyses.
- Permit us to approach the investment implications of climate change probabilistically, by generating a weighted mean across the scenarios and identifying the distribution of risks around that mean.
- Facilitate regular adaption of assigned probabilities as the underlying political, policy and technology drivers of the different scenarios change.

Our exercise includes 15 scenarios in total – including our baseline (which captures what is priced into securities) and the probability-weighted mean across each scenario. This is made up of the NGFS reference scenarios where all policy parameters are taken as given, and eight 'bespoke' scenarios in which we vary the policy parameters by geography and sector across important dimensions. We also apply our scenarios to different integrated assessment models (IAMs) that embed different assumptions about technology and abatement cost curves. This allows us to analyse the sensitivity of our scenario results to plausible alternative technology pathways.

We use the off-the-shelf scenarios to benchmark our analysis against those most commonly modelled by regulators and other users of climate scenarios. But the bespoke scenarios drive most of our results, and the investment decisions derived from that analysis.

The most important takeaways from our analysis are that:

1) The transition to a lower-carbon global economy is highly likely to continue, albeit not on a Paris-aligned pathway. Even in our mean scenario – which implies warming of around 2.3°C - the non-renewable energy share in the global energy mix declines substantially thanks to stricter policy and the increased penetration of low-carbon technologies.

2) This transition will be highly uneven across sectors and geographies because the politics of climate mitigation vary a lot across the major economies, and abatement opportunities vary significantly across sectors. The power sector is the most likely to decarbonise on Paris-aligned timeframes, and the industrial and buildings sectors the least.

3) Solar photovoltaics (PV) is likely to be the biggest winner from the energy transition. Onshore and offshore wind also account for a rising share of the energy mix in most scenarios, albeit with weaker growth than solar except when pessimistic assumptions are made about future improvements in solar efficiency and storage capabilities.

4) Among the fossil fuels, the outlook for coal is especially dire while peak oil demand is likely to be just over a decade away. Natural gas has a larger role to play in the energy mix, but the demand outlook varies considerably, while its long-term outlook depends heavily on the extent to which the cost of renewable-energy technologies continues to fall rapidly and whether carbon-capture and storage technologies become more cost-competitive.

5) Climate-related risk and opportunity is largely a micro or stock-specific phenomenon. The impact of climate change on returns for aggregate global equities is very modest, a +/- 2% impact on aggregate valuation in most scenarios. Aggregate effects on regional indices are also generally modest because of their diversification.

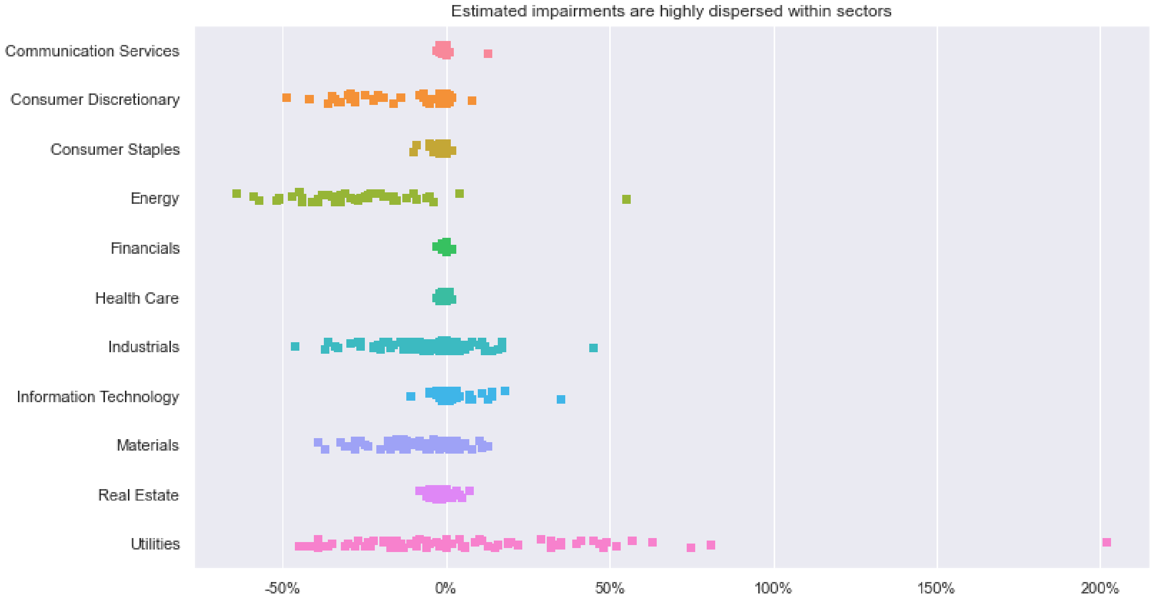
6) At the sector level, global utilities are the largest winner and fossil-fuel energy the largest loser. Indeed, there is no bespoke scenario in which the global utility sector suffers negative equity and credit impairment, with upsides above 30% in most strict climate-action scenarios because of rising electrification. By contrast, the only scenario in which the fossil-fuel energy sector does not suffer an average negative impairment is if there is no scaling up of current climate policies.

7) Within aggregate sectors there is great dispersion across sub-sectors, firms, and regions (see Figure 9). The largest risks and opportunities are concentrated in the energy, utilities, industrials, materials, and information technology sectors. Renewable-energy-based utilities significantly outperform coal utilities; copper and lithium miners do much better than coal miners; and oil-

equipment manufacturers lose out to battery, wind-turbine, and solar-panel manufacturers.

8) This implies a large opportunity to draw on scenario analysis to add alpha to actively managed investment portfolios. There are also more systematic opportunities for investment strategies that tilt towards climate-transition winners and for thematic climate-solutions portfolios.

**Figure 9: Aberdeen's dispersion of outputs from disorganized scenario modelling**




Dispersion of total impact across all companies in the MSCI World Index for each sector (probability-weighted mean scenario). Source: Planetrics and ASI analytics, September 2022

## Next steps for scenario analysis

This section outlines the key priorities for improving scenario analysis capabilities at asset managers over the coming years.

### Data quality

This a collective issue that asset managers face, especially in private assets. Whilst in many cases it is great to just have an estimate, modelled outputs are only as reliable as the inputs are complete and accurate, and if this challenge is to be overcome significant investment is likely to be needed in both estimation, data capture and disclosure by investees. Introducing understanding and hierarchy in the likely data quality is a foundational principle to improvement going forwards, as this can be fed through into qualification of outputs, engagement activities (to disclose) and future prioritisation for improvement. Two actionable areas focus in on the engagement with corporates. Firms have sought to survey their private assets with a view to obtaining information that may already be available internally. In tandem, stewardship led engagement can seek the public reporting of corporate data (e.g. scope 1,2,3 emissions) within a certain time-frame and to a specified quality standard (assurance).

### Location Data

Further limitations arise to the mapping of corporate assets to develop a robust view of exposure to physical risk impacts. Cataloguing physical assets, their location, and assessing financial materiality for public corporates is a huge challenge. This requires information that is not readily available and which corporates are highly reluctant to release into the public domain, understandably. Whilst this is a weakness for public market assets, it's a real advantage for asset classes where there is direct control of the asset, for example in direct real estate or infrastructure investment funds.

Some physical risk models operate on a regional basis, whilst others have impressive granular ability to site of ~5 or $10m^2$. With some real assets, such as infrastructure, there is a challenge of conducting these studies on a distributed basis, such as a railway or a set of telecoms cables, which may be spread over many miles with many critical touchpoints. Whilst these models have impressive capabilities, they are currently expensive, necessitating a prioritisation of key locations to be analysed.

### Understanding limitations

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 how accurate the models will be in the long run. 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.

The time horizons over which climate-related risks may be realised are uncertain, and their full impact may crystallise beyond most current business planning horizons. Social tipping points may not be captured, where some transition elements could affect certain sectors abruptly. Using historical 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. Exploring, understanding, and cataloguing these limitations allows the identification of where the models may have limitations and where the outputs may need to be supplemented with a qualitative overlay.

### Curation of modelling capabilities

Organisations are increasingly looking to develop their own custom scenarios. For example, to test the upcoming political uncertainty of certain climate policies ahead of an election, or specifically test the impact of auto investments if ICE engines were banned in the United States five years earlier than planned. These outline plausible representation of what is likely to occur in order to identify possible actions. Of course, this requires a high level of internal capability as described above, coupled with model support and customisation.

In order to take scenario analysis forwards, and support the breadth of adoption, there is a need for solutions across the capital structure. Particular points of highlight would be in structured asset classes (e.g. ABS, MBS and CMBS) but also down-the-line fund of funds (i.e. private equity funds). This is best achieved by collaborative efforts amongst stakeholders across the industry. Whilst the internal ownership of the firm’s model decisions necessarily resides with a climate expert, those who own the models have had the responsibility to curate and expertly develop them collaboratively with clients.

### Engagement outcomes

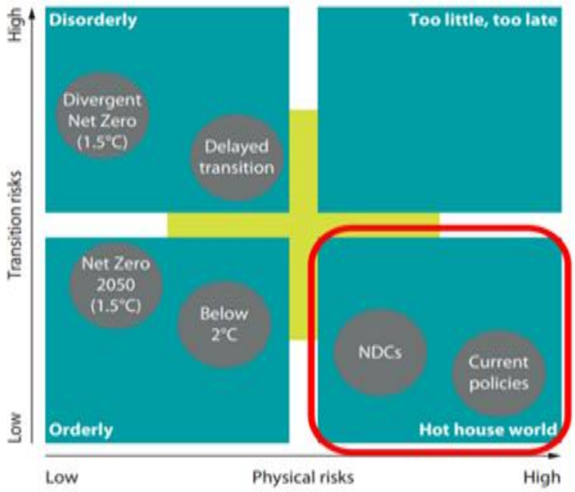
Maximisation of the process to identify material hotspots of climate-related risk across the firm will likely require collaboration across investment research, sustainability, and stewardship functions. Stewardship functions are likely to tackle both investment team-initiated engagement, as well as run climate engagement programmes. Such a target list can be compiled by investees with highest climate-related risk, such that the corporate can be engaged to improve their transition, adaptation planning and disclosure.

# 2. Development of climate reference scenarios

Central banks, the Network for Greening the Financial System (NGFS) and other financial authorities and international bodies have developed a number of climate scenarios. These scenarios – and the, albeit still nascent, exercises that have drawn upon them – are designed to inform decision making and assess financial risks that might arise with the transition to an economy with net zero emissions. Under these scenarios, financial sector exposures to climate-related risks are estimated from a combination of the following:

- Temperature alignment and emissions pathways.
- Technology pathways set out in the energy systems, or integrated assessment models with which they interact.
- Explicit and implicit carbon price pathways that close the loop between emissions trajectories and technology and abatement cost curves.
- Pathways for high level macroeconomic and financial variables like economic growth and interest rates that are consistent with these scenarios.
- More granular information available from financial and climate reporting databases that allow sector, firm, and security level exposures to these scenarios to be modelled and estimated.

**Figure 10: NGFS scenarios Framework**




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

The NGFS temperature alignment and emissions scenarios are based on three main groups of scenarios:

a) **Orderly scenarios** in which policy action consistent with a given emissions reduction and temperature objective begins immediately, limiting physical and transition risks.

b) **Disorderly scenarios** in which delayed or divergent action towards a specific objective increases the long-term costs of that transition to the economy and financial assets as a whole.

c) **Hot house world scenarios**, including:

   i. Scenarios that simply model the effects of nationally determined contributions (**NDCs**) governments have pledged as part of the Paris Agreement.

   ii. Scenarios that model the effects of a stasis in policy that is inconsistent with net zero objectives ever being met and for which financial risks primarily relate to physical climate impacts (**Current scenarios**).

Such scenarios generally consist of macroeconomic variables (e.g. interest rates, economic growth and commodity prices) that financial institutions can use for stress tests and for evaluating financial risks. Taken together these scenarios have already proven to be a useful tool in policy advocacy. For example, they demonstrate the feasibility of the transition to net zero emissions, and the sizable economic benefits of a transition that is orderly.[16]

One possible area in which such official-sector reference scenarios could be improved concerns the degree to which they can be used to assist with asset valuation, investment decision making or strategy evaluation by financial institutions. In particular, assessing the value of financial exposures generally requires a more detailed understanding of the factors affecting the supply of and demand for products on a granular/sectoral basis, rather than at the high-level basis given by macroeconomic variables in reference scenarios. For example, demand for a commodity (e.g. copper) is likely to be a greater determinant of the profitability of, say, the mining sector, than are aggregate macroeconomic variables such as economic growth[17]. While progress has been made to bolster the sectoral granularity of reference scenarios in recent iterations, there is still work to be done in this area.

### From delayed transition to disorganised scenarios

Scenarios involving disorderly transition[18] are the main way in which official-sector reference scenarios currently capture the possibility that the move to net zero emissions might entail a delayed and sharp materialisation of transition risks. Such a scenario typically considers the possibility that policies to reduce the physical effects of climate change are introduced sometime in the future (i.e. delayed). The magnitude of policy change required to achieve net zero goals is therefore much larger, and brings with it radical shifts in economic activity, and a sharp repricing of financial assets that may have negative implications for financial stability.

Reference scenarios along these lines produced by financial authorities tend to be fairly stylised. For example, a given scenario generally assumes that climate policies across major emitting countries and sectors are fairly similar, matched for example with respect to timing and or magnitude. They have, however, been a useful tool for policymakers in so far as they demonstrate the feasibility of, and economic benefits associated with, an orderly transition.

But a delayed or divergent transition to a lower carbon economy is far from the only - or even the most critical – way in which transition risks could have negative implications for financial stability. Scenarios displaying critically negative implications for financial stability typically involve widespread mismatches in the demand for/investment in products and services – either over time, or across geographies or supply chains.[19] Hereon, **we reference such scenarios as 'disorganised' scenarios.**

Sources of 'disorganisation' - which are not currently captured in a detailed way in official-sector reference scenarios - include:

- Discontinuities in the pricing and production of the commodities and technologies that either underpin the current global energy system or will be needed to underpin the net zero energy system of the future.
- Probable variations in the extent to which climate policies and regulations of different countries, and the major emitting sectors within them, are aligned with particular temperature and emissions objectives.
- Probable variations in the extent to which climate policies and regulations affect different parts of supply and value chains for a given end product or service.

Any of these sources of disorganisation could result in a mismatch between the demand for/investment in a particular product, technology or source of energy and its supply. While market prices will always adjust to shifts in demand and supply, if such movements in price are very sharp (or if there is no market price at which supply and demand clear), they can lead to material shortages or surpluses of key primary, intermediate and final goods and services, causing significant volatility in commodity/asset prices, and in extremis leading to the widespread stranding of assets, bankruptcies and credit defaults.

[16] See "(a) Orderly scenarios" above.
[17] As while these have a bearing on aggregate demand and interest rates, they will only partially explain commodity prices.
[18] See "(b) Disorderly scenarios" above.
[19] In this case it would be in high and low carbon products, services and solutions

This could, in turn, lead to widespread financial distress, with negative implications for financial intermediaries and the macroeconomy.

While the current range of reference scenarios can generate higher default probabilities, large declines in equity valuations and even stranded assets, these types of discontinuities are generally under analysed.

## Different types of disorganised scenario

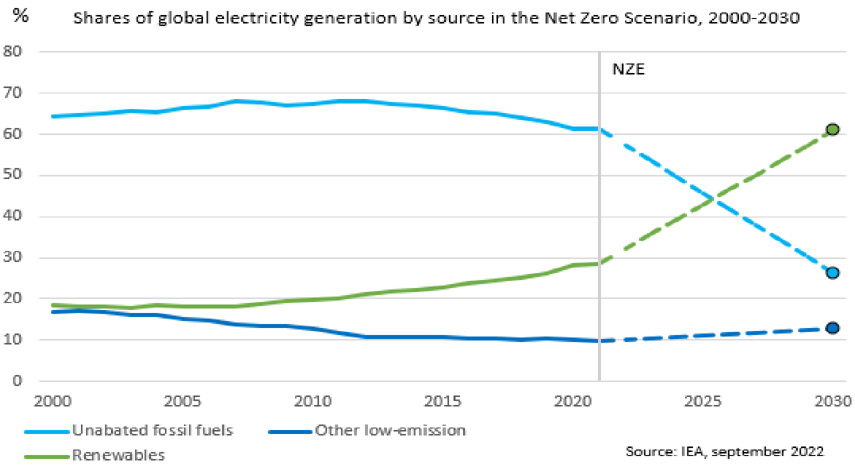
There are three types of disorganised scenario that could be considered in greater detail:

1) That where the near-term investment in, and hence the supply of, carbon intensive goods and services outstrips plausible long-term demand. This would lead to wide-spread write-offs (or 'stranding') of carbon intensive assets at some point in the future, potentially jeopardising financial and economic stability. Note that these assets could reside either in public markets or be transferred to private markets and the state-owned sector where reporting requirements, oversight, and investor action is less advanced. Such a scenario is already captured to some degree in the disorderly reference scenarios produced by the official sector. Although such a scenario remains plausible, trends in investment suggest it is a declining risk.

2) Where the supply of zero and low carbon goods and services significantly exceeds plausible long-term demand. This could occur because, for example, shifts in consumer preferences do not occur fast enough to drive sufficient demand for low carbon products and services. This, admittedly less likely scenario, could lead to a wave of defaults across the zero and low carbon production sectors. However, we consider this less of a risk to financial stability because such firms producing low carbon products and services (as well as the technology to support them) comprise a relatively small a share of current financial assets.

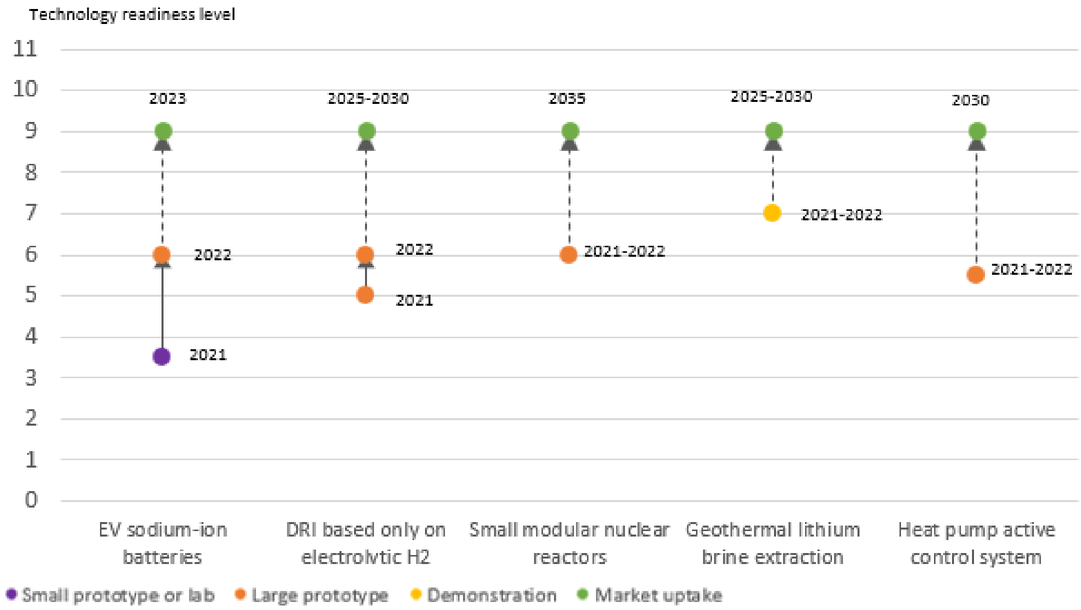
3) Where the near-term investment in, and hence the supply of, carbon intensive goods and services falls quickly, relative to underlying demand for them, but cannot be replaced in a timely manner by growth in the supply of zero and low carbon intensity goods, services or energy (or the technologies to support them). Arguably aspects of this scenario are playing out in economies and markets today, amplified by the war in Ukraine. In the aggregate, governments, financial institutions and companies have been scaling up their climate transition commitments over the past decade. This, together with favourable technology developments, has facilitated stronger investment in low-carbon energy technologies, than in high-carbon energy technologies (see Figure 11).

**Figure 11: The renewable energy share of electricity generation has increased moderately**




Although it is uncertain which, if any, of these disorderly scenarios will be realised, there is evidence to support the possibility of a type 2 disorderly scenario. Although the global energy mix is changing in the right direction (i.e. towards renewables), policy credibility gaps, twinned with uncertainty about future climate and energy policies, as well as the naturally gradual pace of technological change and energy infrastructure development, have kept the aggregate rate of energy investment below what is necessary to meet demand at prices many households and businesses can afford. It has also left the energy system highly vulnerable to sharp positive demand and negative supply shocks, like the recovery from the pandemic, unusually hot summers and cold winters, and the war in Ukraine. Meanwhile, clean technology readiness, as well as investment in sectors such as renewable energy, electric batteries and the extraction of commodities necessary for transition (e.g. lithium and copper) are estimated to be falling short of the levels needed to replace lower fossil fuel use, at least along Paris-Aligned transition pathways (see Figure 12).

**Figure 12: Clean energy readiness insufficient to support a rapid energy transition**




"Technology readiness refers to the maturities of the technologies required for being on track with the IEA's Net Zero Emissions by 2050 Scenario."

Source: IEA, October 2022

While prices are adjusting to supply shortages in carbon intensive sectors, increases in the price of carbon intensive energy can be severe enough to jeopardise the stability of the economy and financial markets. Higher prices for carbon intensive energy can also undermine public support for the energy transition itself, at least to the extent that they encourage additional investment in less clean forms of energy. Indeed, a key feature of the energy transition, which may warrant further exploration, is the likely sensitivity of energy prices to short-term demand and supply shocks, which could be compounded by financial positioning and exposures.

## Sector and geographic dispersion

Another possible limitation of existing reference scenarios concerns the assumptions they make about the evolution of climate policies and regulations. Most NGFS and central bank reference scenarios, for example, assume parallel paths for key macroeconomic variables across different sectors and geographies, although key economic, energy and emissions variables are downscaled in the NGFS scenarios to about 100 major countries. . While assessing climate exposures on the basis of, for example, a common global carbon price can ensure that models are tractable, it is a long way from the world we currently live in and there are limited prospects for a system of common global carbon prices to be initiated in the future for obvious political reasons.

In reality, it is very likely that some sectors will transition to net-zero emissions relatively rapidly, while others will lag. For example, it is widely anticipated that the global power (electricity) sector will decarbonise more substantively by 2050 than the global buildings, industry and agricultural sectors.

Varying decarbonisation trajectories are also possible across geographies. For example, it is anticipated that developed economies will decarbonise more substantively than emerging economies, including China, and that within the developed economies, the European Union is on a more credible decarbonisation trajectory than non-European countries. This is partly due to the differences they face in the costs of reducing emissions, as well as differences in political preferences and incentives, as well as obstacles in ensuring international coordination.

It is therefore unlikely that transition across sectors and geographies will proceed in and organised fashion, with supply and demand for carbon intensive and renewable products and services proceeding in lockstep. These differences could have substantial bearing on any assessment of financial exposures. Sector and geographic policy dispersion now and into the future means that formal and shadow carbon pricing across these major sources of emissions vary significantly. That in turn means that the actual carbon costs, potential demand creation and destruction, ability to pass higher carbon costs on to end users, and hence outlook for firms' revenue, earnings, default probability and valuations will look very different from the output of models that assume policy universality. The difficulty in capturing these effects in official-sector references scenarios therefore significantly reduces their usefulness in financial institutions' investment management and decision making.

## Developing disorganised scenarios as an investment tool

For reasons described above, the next generation of official-sector reference climate scenarios could perhaps consider some element of 'disorganisation': that is, the possibility that demand for/investment in high and low carbon products, services and technology is imbalanced across time, geography and/or supply chains. One of the difficulties in capturing disorganised scenarios is the number of potential combinations of different transition paths across different sectors/geographies of the global economy. Whereas current official-sector reference scenarios tend to assume that all elements of the global economy work together to achieve a certain climate goal[20] modelling disorganised scenarios would require the development of different transition scenarios for different elements of the global economy.

One way to do this might be to:

- First, develop granular models of transition across a few material sectors (e.g. oil, gas, steel etc). This would give paths for changes in technology, policy, and demand across each sector under a plausible transition scenario.
- Second, develop models that translate these sector-specific paths for technology, policy and demand to macro variables (e.g. capital investment, labour, growth, etc.) specific to each sector.
- Third, evaluate the impact of these variables, which would be consistent with transition in each individual sector - on the balance sheets and solvency of financial institutions (real or hypothetical) with exposures to these sectors.

Disorganised scenarios would have the potential to illustrate the possible effects of disorganisation on different economic sectors and associated financial assets relating to them. In doing so, they might provide insight into what mixtures of official-sector policy are likely to be constructive in mitigating such risks. Such scenarios might also provide a tool with which financial institutions and investors can assess the effects of such scenarios on their investment portfolios and establish strategies to mitigate these.

[20] Although, it should be noted, that the NGFS' Divergent Net Zero scenario attempts to capture a world in which the policy landscape is fragmented.

# 3. Considering adaptation in scenario analysis

Climate adaptation refers to the level of change required from society, organisations, and governments in response to observed or projected climate change. The IPCC[21] defines adaptation as 'the process of adjustment to actual or expected climate change and its effects'. This section explores how climate adaptation is considered within scenario analysis today, and how this could improve in the future. It covers the difficulties in achieving the level of granularity needed within most asset classes for many asset managers, ways in which both physical risks and adaptation may impact entities, how cost-benefit analysis could be used, and how asset managers can assess both the risk and opportunities with respect to adaptation and the impact of counterparties' adaptation planning.

## Scenario analysis and climate adaptation

Within climate change scenarios, the link between climate change, climate impact, socio-economic structures and damages is complex. The type and level of adaptation is subject to considerable uncertainty. This is because it requires an understanding both of known and projected climate states, as well as assumed levels of social response and changes in human behaviour over time.

The IPCC sixth assessment report has estimated that human activities have already caused approximately 1.1˚C increase in global temperatures compared to pre-industrial levels. The continued emittance of greenhouse gases will lead to further temperature increases and other climatic changes long into the future. The longer the delay on mitigation, the higher the vulnerability and potential impact faced from climate change. This demonstrates both the need to consider adaptation in the present day due to already induced future warming and to understand the potential levels of adaptation needed in the future.

The Stern Review, estimated that mitigation would cost 1% of GDP (in 2006), whereas the cost of dealing with unabated climate change could reach 20% or more of GDP in the future. Understanding the range of future scenarios, dependent on levels of mitigating action, is critical to understand the non-linear relationship between delayed action and adaptation.

Whilst investments could be directly impacted by physical risk events, other indirect risks could also arise such as the disruption of supply chains, increased costs of insurance premia and broader changes in consumer preferences, behaviour, and broader economic activity.

Certain industries will have a heightened need for adaptation given inputs to production, asset intensiveness and inherent characteristics; other industries may face an inability to adapt to the extent required. For example, the power sector is particularly vulnerable to physical risks, both acute (e.g. the possibility of a greater frequency and intensity of severe weather events) and chronic (e.g. rising temperatures) as the sector is reliant on water for fuel and cooling to achieve specific temperature balance. Rising temperatures, changing precipitation patterns, and increasing severity of weather-related events risk causes losses for firms in this sector. Whilst elements of the impact of sustained rising temperatures and heatwaves are clearly modelled, other channels of risk - such as the energy sector's dependence on cool water are often not covered, due in part to the detailed information on assets that this requires. In EBRD's assessment, in collaboration with the WRI, increasing water temperature accounted for over 80% of the physical risk losses associated with coal and hydro electricity generation.

Climate scenarios provide a systematic and a general stylised representation of physical risks, usually at national scale. One difficulty in incorporating climate adaptation into these scenarios is the need for granular data on the location and nature of firms' assets. This is particularly the case in developing markets, where data on the location of, and interlinkage between, assets (say, via their supply chains), is particularly scarce. Even where such data is available, further complexity is involved in assessing and quantifying how firms' adaptation will affect risks.

[21] IPCC AR5 Synthesis Report - Glossary

Physical risks each give rise to vastly differing levels of financial cost in terms of the adaptation efforts needed to limit their impacts, potentially restricting a counterparty's capacity to cope with climate change. The significant level of capital needed is already visible; COP26 urged developed nations to at least double their collective provision of adaptation finance from 2019 levels by 2025; and at COP27 an agreement was reached to establish a fund to respond to loss and damage resulting from climate change (Loss and damage fund for vulnerable countries), which aims to help developing countries affected by climate change through funding from developed countries or wealthy countries.

Figure 13 outlines some of the mechanisms and associated impacts that could stimulate investment in adaptation and resilience measures in order to reduce their effects. If scenario analysis does not incorporate the effects of these adaptation and resilience measures, then it may both overstate physical risk and not be useful with respect to identifying adaptation and resilience investment opportunities.

**Figure 13: Mechanisms and associated impacts that could stimulate investment in adaptation and resilience measures in order to reduce their effects**

| Mechanism | Impact |
|---|---|
| **Cost of crystallisation of physical risks themselves – damage and activity losses** | Direct damages from physical risks can bring damage to both physical assets and infrastructure – adding a cost burden to both corporates and assets. Lower revenues and increased costs can also occur from the disruption to company activities and ability to transport and distribute products. The impact of such physical risks depends on the location of the assets and level of materiality. |
| **Cost of crystallisation of physical risks themselves – increased costs** | Locations that face on-going physical risk disruption could face increased costs given higher insurance costs or even an inability to acquire insurance coverage. The level of increased costs could impact the economics of an asset or company functioning. |
| **Ability to Finance Adaptation – relocation losses** | A sustained difference in conditions within an area from climate change can impact the functioning of an asset or company. In some cases, an entity may struggle to continue to operate within this location – due to an inability to finance the adaptation measures required or even the lack of adaptation options. This would incur huge costs to an entity in terms of the relocation of operations. |
| **Ability to Finance Adaptation – altering workforce output** | A sustained difference in conditions within an area due to climate change could also impact the level of an output a workforce is able to achieve. For example, increased temperatures can lower the level of productivity a workforce is able to operate at, reducing the overall output of a company and potentially lowering revenues. |
| **Supply Chain Dependences – access to materials, trade economic flows etc** | Materialisation of physical risks can indirectly impact a company through disruption to their supply chain, both upstream and downstream. For example, this may affect the ability to access materials and the costs of those materials. |

Whilst understanding adaptation is best undertaken at a more localised level, to result in a better risk assessment, a balance needs to be struck between a more systematic approach taken through using familiar reference scenarios vs. specific asset location-based assessments, given the level of data availability at this level.[22]

Where scenario analysis is able to link investments or assets to geographical results this tends to be at the operational level rather than exploring supply chain linkages. Supply chain assessments remain the hardest to calculate, or to capture in scenarios. At present, where this level of scenario analysis is

[22] XDI is an example of specialised data provider that assists both asset owners and governments to quantify the cost of extreme weather and climate change impacts. The output from XDI's capabilities enables time series climate change assessment at multiple levels of granularity from area or business down to individual asset.

performed or required, then it will generally take the form of a qualitative rather than quantitative assessment. For many, this consideration is assumed to be covered by insurance, under business operating costs, but is not isolated and measured by internal management systems, potentially creating the risk that gaps in protection are missed or unexpected and potentially unaffordable insurance costs are incurred.

## Case study: water levels on the Rhine River

An example of supply chain disruption and the potential for knock-on impacts is given by changes in the water levels, due to changing rainfall patterns, on the Rhine, one of Europe's major inland rivers, connecting ports to Germany's industrial hub and Switzerland. The river has experienced persistently low rainfall, altering the depth of the Rhine, affecting trade routes and the shipment of coal, chemicals and other commodities to power plants and factories. German GDP was impacted by an estimated 0.5% in the third quarter of 2021 as a result.[23] These effects were also shown in the extra costs and impacts to profit expectations of certain listed corporates which needed to adapt production and supply chains.

## Cost-benefit analysis in climate adaptation and decision making

Cost-benefit analysis is a framework commonly used to structure analysis and aid necessary collation of materials to evaluate and approve investment. Where there are many assets, it will likely be necessary to conduct a preliminary high level risk mapping and screening exercise first.

Currently the cost of screening many assets may necessitate a high-level approach to the projection of physical risks into the future. Following this preliminary analysis, the next stage would be to conduct deep dives on those assets flagged as higher risk. Section 1, Case Study 2 illustrated how this approach could be run on a real estate portfolio.

The use of cost-benefit analysis to incorporate climate adaptation considerations into investment decision making process can be valuable when for example:

1. Conducting due diligence on new potential investments to prevent unintended purchasing of additional higher risk assets;
2. Considering if adaptation of the asset to climate-related risk could have a positive net present value impact (i.e. the market value is cheap given a plausible detailed plan to adapt and make the asset more resilient).

One key factor to bear in mind is that some key physical risks are harder to model today than others. In addition, even where physical risks are modellable in the immediate locality, issues nearby like flash flood risk up valley, may be less easily identified and captured.

Furthermore, for most assets, transition risk is likely to manifest itself sooner than physical risk, even if you consider the fat tailed nature of physical risks and that they could be influenced by tipping points. Most real assets tend only to be subject to significant physical risk effects post 2050, although some may be impacted earlier – i.e. in the 2020's, 2030's or 2040's. However, we also know that these risks are likely underestimated by models today.

Running scenario analysis on a range of RCPs including more likely central scenarios as well as tail scenarios will help to determine the cost benefit of different adaptation solutions depending on future temperature rise and associated physical risk[24]. Tail scenarios can also help identify non-linearity issues.

[23] https://www.reuters.com/markets/commodities/low-rhine-water-levels-another-drain-germanys-economy-2022-08-10/
[24] https://www.lse.ac.uk/granthaminstitute/publication/the-unconditional-probability-distribution-of-future-emissions-and-temperatures/?mc_cid=a3b25d5c5f&mc_eid=c15cf331f4

Key issues that need to be considered in climate adaptation investment are:

- At what point along the timeline could insurance costs and availability become an issue (foresight of economic agents can also be a factor)?
- In what location does the adaptation investment need to be? Does it rest within the owned and controlled perimeter, or may it be more effective in areas owned and controlled by other stakeholders? For example, access to a shopping centre at risk of flooding will likely depend upon not just fixing the flooding in the car park, but also in the surrounding transport links such as the road and rail network so that customers can still access the centre.
- Who benefits and to what extent? Is there a free rider issue? For example, establishing flood defences for a property can inadvertently benefit or cause problems for other stakeholders in the vicinity or downstream. Shared co-investment would reduce the burden of a single stakeholder.
- If the investment does not stack up due to the free riding, to what extent can the local principality or government step in given their wider interest in communities to co-ordinate investment? An example would be the Thames barrier upgrade to protect London.
- Do the benefits sit so far in the future that investment may be delayed until impacts begin to be felt commercially or sit within the business planning horizon? Are and will these factors begin to be factored into market values today (foresight)? What is the risk that the models underestimate physical risk?

Addressing these issues will also support development of scenario analysis processes aided by clear two-way exchanges between investment decision makers and the model (and its owner).

## Incorporating assessments of adaptation into scenarios

Whilst for direct physical risks, climate scenarios can at least draw a proxy for the potential size of impact, secondary indirect risks relating to adaptation remain more limited. The uncertainty largely relates to a number of unknowns:

1) Materiality given location of specific asset; the balance between physical and transitional risks for each asset, the interplay with company levels, and the ability to diversify and dampen materiality.

2) Asset class specificities; real estate is most likely to be able to assess assets both for physical risks and for adaptation resilience. Even for other real asset investments, such as infrastructure, complications can occur where you cannot pinpoint a specific location to assess for physical risk and adaptation required (e.g. a telecommunications network).

3) Levels of committed adaptation planning through international cooperation; Countries' National Adaptation Plans and consideration of future climate resilience in corporate business strategies.

4) Countries and companies' ability to finance the required levels of adaptation.

5) The level and timing of mitigation action; determining the level of adaptation and/or physical risk.

Whilst climate impacts on social standing such as well-being, migration and conflict are explored within some scenarios and through specialised reports, such as the IPCC or Lancet Commission on Health and Climate Change; the social disruption to and vulnerability of individual companies is less well understood. This level of risk assessment would require both assumptions on future climatic states coupled with company level data on their relationship to social stakeholders from both an operational perspective and through their supply chain.

Figure 14 shows some of the opportunities for investments in different asset classes to fund and catalyse adaptation. Whilst largely considered in the form of a risk from climate change, the investment industry could also see an upside to adaptation or adaptive capacity, through investments in adaptation related solutions and where companies and/or assets that are under-priced in their upside in terms of ability to finance adaptation and/or level of resilience. Examples of adaptation options/opportunities can be divided into three categories, as used by the IPCC, and can be seen below:

**Figure 14: Some opportunities and risks associated with climate adaptation**

| Category | Options |
|---|---|
| **Structural / Physical** | • Sea walls and coastal / flood protection<br>• Water storage and improved drainage<br>• New crop varieties – through genetic or traditional techniques<br>• Changes to farming and irrigation techniques<br>• Ecological restoration – e.g. mangroves, reforestation<br>• Social structures around food provision, vaccinations, and sanitation / water |
| **Social** | • Awareness through education, research networks etc<br>• Hazard and vulnerability mapping, early warning systems<br>• Planning structures – household, evacuation, migration |
| **Institutional** | • Financial incentives – changes to subsidies / taxes, insurance, catastrophe (CAT) bonds<br>• Laws and Regulations – building standards, social support, land production<br>• Policies – adaptation plans, resource management (forests, water etc). |

Many adaptation actions occur at a local level. Where asset level location data is available, for example for real assets; more granular levels of risk and adaptation analysis can be performed.

However even where overall scenario analysis exploration is limited due to lack of location specific data, asset managers can still make use of scenario analysis. For example, they can:

1) Build awareness of the attributes of different climate scenarios in terms of its assumptions towards physical risk and adaptation to support qualitative narrative-based analysis.

2) Analyse investments at a sector or country level. Note the 'Assessing Sovereigns climate-related risk and integration in business processes' case study in Section 1.

3) Engage with holdings to undertake granular scenario analysis themselves (in line with TCFD reporting) and make this available publicly.

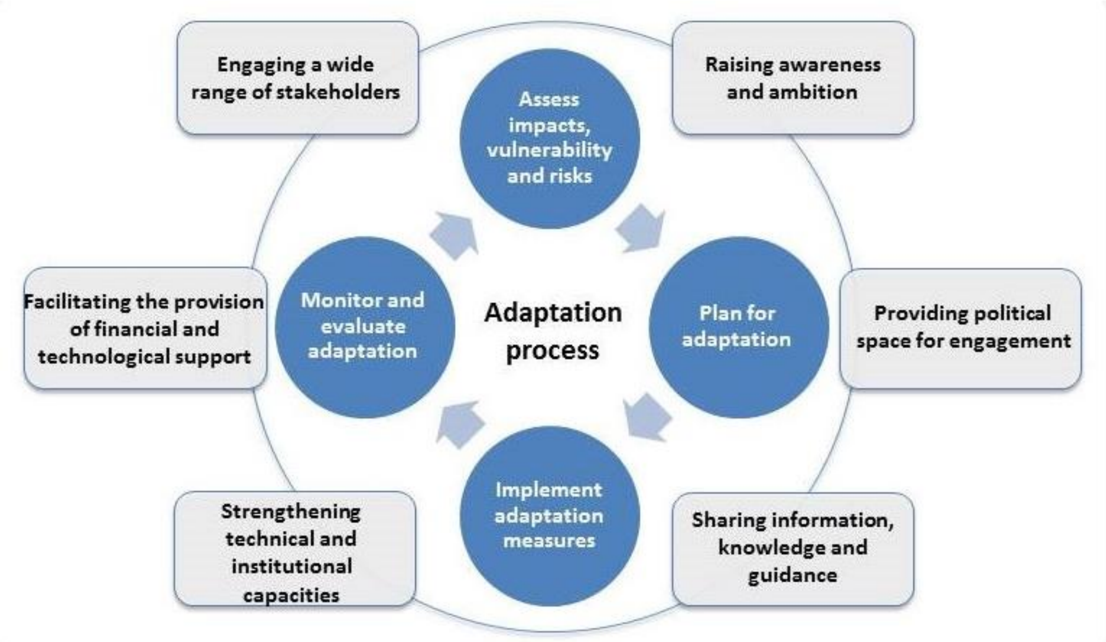
4) Engage related stakeholders and encourage them to undertake and develop joined-up adaptation plans.

5) In consultation with stakeholders identify the measures and output from company level scenario analysis required by investors to include within their own scenario analysis.

## How asset managers could assess counterparty adaptation plans

Adaptation planning is the process of measuring climate impacts, vulnerability, and risks; planning for this and implementing the measures needed to build climate resilience. Adaptation planning is required by multiple stakeholders, from national governments to communities and businesses. National adaptation plans were established under the Cancun Adaptation Framework in 2010. It provided a framework from which parties can formulate and implement medium to long-term adaptation planning in response to climate change. Figure 15 provides an example framework, the adaptation cycle, under the UN climate change regime.

**Figure 15: A framework for assessing counterparty adaptation plans**




Source: [UNFCCC Cancun Adaptation Framework]

Where scenario analysis has identified strong physical risks, direct or indirect, to a relevant counterparty, an asset manager should attempt to understand the level of adaptation planning that has taken place, and the resiliency of the counterparty both at present and under future states. The level of adaptation planning analysis can occur at business, investment or even asset level.

This assessment will likely involve the use of published adaptation plans within a multi-tiered approach, national and city planning, down to individual businesses and assets where possible. Asset managers will need to build resource in understanding the credibility of adaptation plans and the level of resiliency it might provide to investments. Proposed assessment areas of adaptation plans are as follows:

| Assessment Area | Key criteria |
| --- | --- |
| **Assessment of impacts, vulnerability, and risks** | • Shows an understanding of current and future climate changes.<br>• Plan contains use of scenario analysis to examine the various climate-related risks and associated timescales.<br>• Contains assessment of impacts at both an operational and, where possible, supply chain perspective. |
| **Plan for adaptation** | • Should reduce vulnerability and/or increase adaptive capacity of the most vulnerable.<br>• Should be economically, ecologically, and socially sustainable – and understand any trade-offs between these goals. |
| **Implement adaptation measures** | • Outcomes of the adaptation plan are measurable.<br>• Where possible, the plan is disclosed and accounts for the financial costs of adaptation measures. |
| **Monitor and evaluate adaptation** | • Adaptation plans should be monitored over time.[25]<br>• The adaptation plan must be updated frequently to reflect growing understanding of climate science and updated levels of mitigation action.<br>• Each component of the above must be shared as a public assessment and commitment. |

[25] This can be monitored within an asset manager by the research analysts in conjunction with the sustainability team, either monitoring disclosure or engaging with an investee, or where the asset is directly controlled, conducted internally.

There is much to do to improve the models of physical climate risk currently used by asset managers. Mapping of assets to corporates and assessing their materiality using more precise location-based analysis will form an important part of this effort. There exists a clear capability gap compared to insurance models evaluating natural catastrophe and flood risk on a localised basis. Obtaining this information as an input relies upon disclosure by corporates. In the case of some private investments with either direct or substantial influence such as in the case of real estate or infrastructure investments it may be more straight-forward to obtain this information.

Financial firms are generally more aware and have a better understanding of acute rather than chronic physical risks, yet chronic effects are set to increase in coming years. In order to better assess physical risk and the potential for adaptation and resilience, asset managers and model providers will need to develop these capabilities. A first step is screening assets at a general level to identify those with the highest risk.[26] The second step is a deeper dive specific location-based analysis. This will usually be more straight-forward for directly owned real assets than those held by public investments.

With public assets, at present, the best way to acquire this information would be direct engagement with investee holdings, prioritising by the materiality of the manager’s holding. Yet it is currently unrealistic to engage with what is likely to be such a large number of holdings across a firm. Data providers can progress this understanding in a more systematic and extensive way. For this, asset managers need to be conscious of the methodology used by third parties.

A comprehensive climate plan will include the level of adaptation needed and the ability to adapt (from a technological, financial or other perspective). The amount of information and analysis needed for this assessment can be extensive. Where the asset is under direct control or substantial influence, cost-benefit analysis can aid the decision-making process moving from risk identification to adaptation and resilience investment decisions.

Climate adaptation is a key consideration for asset managers within scenario analysis as they continue to understand how climate risks may play out; the preparedness of counterparties and the level of resilience they are currently, and in the future, prepared for. Scenario analysis will need improvements in physical risk modelling, but also the ability to incorporate the reduced associated risks of adaptation plans for assets as they are implemented.

[26] As highlighted in Section 1, Case Study 2: Assessing Real Asset Risk under 2°C and 4°C scenarios by M&G.

# Summary comments

Scenario analysis is a key capability to challenge conventional wisdom to help create more climate-resilient portfolios and firm-wide strategies going forwards by deepening integration into business processes. Section 1 contains: an approach to selecting a model and evolving it with a model use cycle; the action list of organizational process which will be improved with the integration of scenario analysis; and multiple case studies illustrating the plethora of innovative solutions which can be implemented across the industry.

Net zero and climate transition plans of asset managers are evolving rapidly. The development of custom and sophisticated modelling capabilities will support the articulation of both the fund level and asset manager level approaches to climate-related risks and opportunities, but also what might cause them to credibly and tactically alter course in the future.

However, further work is still required to improve scenarios and ensure they cover a wide range of different plausible pathways. In section 2, we described ways in which official-sector reference climate scenarios could further consider elements of non-uniformity across socio-political-economic reality or ‘disorganisation’ to capture how transition risks and opportunities might crystalize as part of the move towards net zero.

Whilst climate plans have primarily focused on the transition and climate mitigation, climate adaptation is much needed and will be a key focus for the future. The ways to begin assessing adaption plans within an asset manager were outlined in section 3, with summaries of risks and opportunities of climate adaptation measures and sets out steps to assess these. Asset managers need to begin with practical steps such as building internal capabilities to enhance scenario analysis for real assets. The priority areas are those where informational inputs and models are currently available. Future steps include the integration of cost-benefit analysis, to decide whether it is financially sound to upgrade and mitigate against physical risks as well as to identify assets likely to stranded in the future. In public markets the key aspects are prioritizing engagement of investees by materiality of exposure and seeking the disclosure of credible climate adaptation plans. These processes have a key role in improving identification and mitigation of climate related physical risk, but also identifying opportunities to invest and financially benefit from adaptation.