



Centre for Regulatory  
Strategy, Asia Pacific

Climate-related risk  
stress testing



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# Introduction

Today's climate crisis urges us to rethink and reinvent our economy. Businesses need to change and meet higher expectations of sustainability, and along with this, higher expectations of their approach to risk management. In the near future, financial institutions' approach to integrating climate-related risks must evolve to face the non-linear, unpredictable, and irreversible nature of climate change.

In 2015, 187 governments took the historic step to sign the Paris Agreement on climate change. At its core, the Paris Agreement is a series of commitments aimed at limiting global warming to less than 2°C above pre-industrial levels, which is thought to be a 'line in the sand' that will limit the worst impacts of a warming planet. This will be a Herculean effort – an international, coordinated economic transition away from fossil fuels and carbon-intensive economic activities that is without precedent in human history.

To achieve these goals, many different actors must meaningfully participate in the transition to a low-carbon economy and help mitigate climate-related risks. The importance of financial institutions in this transition has been underscored from many quarters – supranational and local policymakers, financial regulators, shareholders, investors, the public at large, and influential individuals within financial firms have all voiced their desire to see financial institutions take an active role in responding to the problem of climate change.

Financial institutions are both impacted by climate-related risks and can affect the transition to a low-carbon economy. There are also likely many competing visions of sustainability strategies, differing stakeholder demands, and emerging expectations from regulators. For our region, this becomes even more difficult as we in Asia Pacific will face outside impacts and risks from climate change in the coming years.

Financial institutions in Asia Pacific need to take the integration of climate-related risks into their risk management processes seriously, not only in response to regulatory pressure, but also as a proactive member of the regional and global communities working to mitigate the impacts of a changing climate. As what constitutes best practice in approaches and methodologies to comprehensively manage climate-related risks at financial institutions is very much under development, firms in Asia Pacific need to assert their voice at this critical time.



The tools available to understand, measure, and manage climate-related risks are manifold. Financial firms will need to adopt varied approaches, both within and outside the risk function, to find gaps in their current practices and opportunities for the future.

**This paper will focus specifically on climate-related risk stress testing.**

This area was chosen for **two reasons** – first, it is an excellent entry point for financial institutions to **leverage their existing macroeconomic stress testing capabilities**, and second, we believe that it will be **one of the first climate-related risk management analyses required by supervisors both in our region and abroad.**

This paper will dive into the '**what**', '**how**', and '**why**' of climate-related stress testing, exploring what regulatory changes are coming, how firms can respond, and why Asia Pacific leadership is needed right now.



# Climate-related risks



## What are climate-related risks?

Climate change presents two main categories of risk:



**Physical risk** arises from increasingly powerful and frequent extreme weather events, such as heatwaves, floods, and storms, as well as long-term alterations to the climate including rising sea levels and average temperatures.



**Transition risk** is the result of the need to move to a low carbon economy. Incentivising this transition will require stimulus from governments with many corporate players, investors, and borrowers facing high transition costs. Depending on whether the transition is orderly and efficient, there may be huge opportunities for growth, but there is also a likelihood of stranded assets for companies that are invested in or involved with carbon-intensive industries.

It is important to recognise that the two risk categories interact with one another and cannot be considered in isolation. For instance, increased occurrence of physical risk will likely prompt a policy response, which could, in turn, increase transition risk. The cost of climate risks is felt across all sectors, including financial services.

As will be discussed later in the paper, both the transmission mechanism between climate-related risks to financial risks and the complex interconnection between climate-related risks can pose modelling challenges.

### Outsize impacts to Asia Pacific

Views on the pace of a transition away from a carbon-based economy are mixed. Some commentators are optimistic that strong globally coordinated action both by governments and the private sector will result in an orderly transition away from a carbon-based economy. Others are less so, and believe that a transition may be uncoordinated or disorderly.

Whatever the shape of the change, there is a host of evidence that shows that our region is likely to be disproportionately affected by both physical and transition risks. While climate-related risk stress testing will be important for all financial firms, the case can be made that Asia-based financial firms will need these capabilities given the extent of their exposure to climate-related risks.



### Physical risks

The World Economic Forum (WEF) notes that Asia Pacific witnessed 50% of the world's natural disasters in 2018, affecting 50 million people and costing the region US\$ 56.8 billion.<sup>1</sup> This has been echoed in a report published by a consortium of private sector and non-profit actors from Asia Pacific where they highlight that "Asia has the highest cost exposure of all regions globally to extreme weather...This reflects the density of population, industrial production, and the high proportion of coastal areas in the region".<sup>2</sup>

While climate change does not directly cause extreme weather events, it does exacerbate them. The aggregate effects of more frequent and destructive extreme weather events, along with other environmental stressors amplified by climate change, are certainly cause for concern for the region.

Human response to the physical impacts of climate change should also be considered. For example, Indonesia resolved to move its capital from Jakarta over the course of 10 years starting in April 2019 because the coastal city was vulnerable to rising sea levels, among other climate-related risks, and is expected to cost roughly US\$ 33 billion.<sup>3</sup> Singapore, a low-lying island city-state, expects it will need to spend US\$ 72 billion to climate-proof the city over the next century.<sup>4</sup>



### Transition risks

Asia Pacific also faces a high level of transition risk arising from a combination of factors – one such factor is the amount of carbon-based assets on the balance sheets of financial firms in the region. Should public policy towards carbon-based assets shift or technology advance and therefore decrease the price of carbon alternatives, Asia Pacific financial firms could face a significant level of stranded assets, i.e. investments that are worth less than previously expected as a result of changes associated with the energy transition.

For example, coal continues to play an important role in the economies of China, India, South East Asia and Australia, and many Asian banks are significant financiers of fossil fuel firms.<sup>5</sup> Coal still accounts for 57.7% of China's energy consumption<sup>6</sup> and stock exchanges in Shanghai, Shenzhen, and Hong Kong SAR are vulnerable to value destruction should there be a structural shift in China's coal assets.<sup>7</sup> This poses significant transition risk - the Chinese government recently announced to the United National General Assembly their plan to see Chinese CO<sub>2</sub> emissions peak in 2030 and achieve carbon neutrality by 2060.<sup>8</sup> Recently, there has also been some movement by Asian financial firms to mitigate these risks – Japanese banks, for example, were among the top lenders to new coal projects in Asia but many have since pledged to end financing for such projects.<sup>9 10</sup>

Coal is only one example of the unique transition risks faced by Asia Pacific. It remains to be seen how we as a region will thread the needle of growth that is currently fueled by carbon and the reality of the coming transition away from a carbon-based economy.

### **A global response to a global issue**

In recent years, there has been significant and coordinated movement at the supranational level to improve both corporates' and financial institutions'

approach to managing and disclosing climate-related risks. Most notable are the efforts of the Task Force on Climate-Related Financial Disclosures (TCFD) and the Network for Greening the Financial System (NGFS).

The TCFD was formed by the Financial Stability Board (FSB) in 2015 to develop a consistent set of climate-related financial risk disclosures. The NGFS is a global forum for financial supervisors to share their experience and knowledge on integrating climate risk into their supervision of financial firms' risk management processes. The aim of their activities is to produce research and recommendations that can be implemented through regulation and/or requirements at a national level. In Asia Pacific, 13 regulators are amongst the 72 member regulators globally.<sup>11</sup>

The work done by both of these organisations is evidence that climate-related risks are now being considered as a fundamental financial risk that is expected to be embedded throughout an organisation and overseen at the Board and C-suite level.

### **Regulatory implications for financial firms**

The TCFD has released widely adopted guidance for corporates and financial institutions to better identify and disclose the potential financial impacts of climate-related risks and opportunities on their businesses.

**Figure 1: Core elements of recommended climate-related financial disclosures<sup>12</sup>****Governance**

The organization's governance around climate-related risks and opportunities

**Strategy**

The actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning

**Risk Management**

The processes used by the organization to identify, assess, and manage climate-related risks

**Metrics and Targets**

The metrics and targets used to assess and manage relevant climate-related risks and opportunities

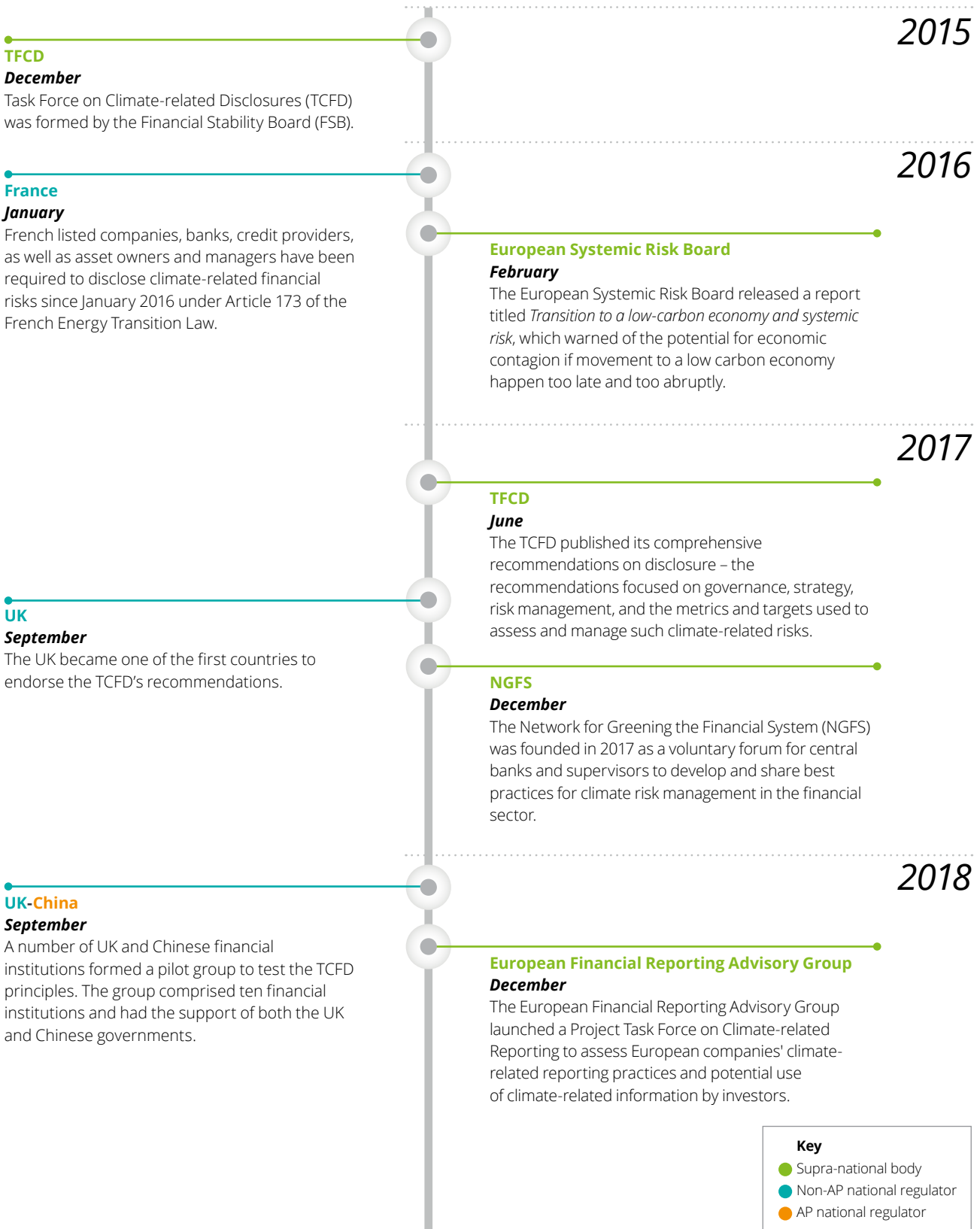
The TCFD recommends climate-related financial risk disclosures across all four of the areas in Figure 1 for both corporates and financial institutions. While the information contained in such disclosures is important, for technical expertise on climate-risk stress testing the work being done by the NGFS is perhaps more salient.

Since its first comprehensive report in April 2019, the NGFS has been publishing at a brisk pace. In their May 2020 paper *Guide for Supervisors: Integrating climate-related environment risks into prudential supervision* they note that “[g]iven the forward-looking nature of the risks and the inherent uncertainty associated with climate-related and environmental risks, supervisors expect financial institutions to develop methodologies

and tools (e.g. scenario analysis and stress testing) necessary to capture the size and scale of climate-related and environmental risks”.<sup>13</sup> Their subsequent publication *Overview of Environmental Risk Analysis by Financial Institutions* and accompanying case studies attempt to lay out a technical guide for climate-related stress testing.<sup>14</sup>

This follows a trend where regulatory activity around climate-related risk management has begun to focus on stress testing as an important first step for financial firms. The following timeline shows how climate-related risk stress testing has been an important focus for regulators since 2019.

**Figure 2: Timeline of climate-related risk management regulatory activity**





2019

**APRA****March**

The Australia Prudential Regulation Authority (APRA) released the results of a survey of 38 large financial institutions, seeking to understand and assess their management of financial risks of climate change.

**TFCD****May**

A group of Japanese corporations, academics, and government agencies inaugurated the Japan TFCF Consortium.

**Bank of Canada****May**

The Bank of Canada listed climate change as one of six major vulnerabilities in the Canadian economy.

**TFCD****October**

The Japanese Ministry of Economy, Trade, and Industry hosted the inaugural TCFD Summit in Tokyo.

**BNM****December**

Bank Negara Malaysia (BNM) issued a discussion paper to the industry, entitled *Climate Change and Principle-based Taxonomy*.

**PBC****December**

Deputy Governor of the People's Bank of China Chen Yulu noted that the Bank would begin to focus on climate-related financial risk analysis.

**HK SFC****December**

The Hong Kong Securities and Futures Commission (SFC) released the results of its *Survey on Integrating Environmental, Social, and Governance Factors and Climate Risks In Asset Management*.

**APRA****December**

It was reported that APRA would bring "tough new institutionally focused climate change stress tests, which will be rolled out following the launch of new economic and environmental scenario modelling by global central banks" in 2020.

**NGFS****April**

The NGFS published its first comprehensive report, *A Call for Action: Climate Change as a Source of Financial Risk*.

**TFCD****June**

The TCFD published their *Second TCFD Status Report*, in which it noted progress in adoption - with the caveat that this adoption was insufficient and needed to be accelerated given the scale of financial risks posed by climate change.

**US Senate****November**

A US Senate bill titled *Climate Change Financial Risk Act of 2019* was introduced.

**EBA****December**

The European Banking Authority (EBA) released an action plan that will require banks to include ESG factors in their risk management policies.

**UK PRA****December**

The UK Prudential Regulation (PRA) published its plan to conduct climate stress testing for lenders and insurers.

**NGFS****December**

The NGFS has grown to comprise 54 member regulators and 12 observers.

**Key**

- Supra-national body
- Non-AP national regulator
- AP national regulator

2020

**APRA**

**February**

APRA published a letter to all APRA-regulated institutions outlining plans to develop a prudential practice guide focused on climate-related financial risks and a climate change vulnerability assessment, which will seek to use climate risk stress testing and scenario analysis.

**ECB**

**May**

The ECB issued a guide for banks on climate-related and environmental risk management. The guidance included assessing the potential impact of climate-related and environmental factors on market risk positions and future investments, developing stress-testing scenarios, and evaluating the benefit of including stress testing into baseline and adverse scenarios for those institutions with material climate-related and environmental risks.

**NGFS**

**May**

The NGFS published *Guide for Supervisors: integrating climate-related and environmental risks into prudential supervision*.

**MAS**

**June**

The Monetary Authority of Singapore (MAS) published a consultation paper on incorporating climate-related risks into annual stress tests; however the methodologies for stress testing such risks are still at a nascent stage.

**NGFS**

**June**

Published NGFS climate scenarios for central banks and supervisors and *Guide to climate scenario analysis for central banks and supervisors*.

**HKMA**

**July**

The Hong Kong Monetary Authority (HKMA) published a circular on climate risk management and will invite interested financial firms to participate in a pilot climate change stress testing exercise and seek feedback from participating firms on scope, scenario and outputs, before formally launching the climate change stress testing exercise in 2021.

**BdF**

**July**

The Banque de France requires stress tests for climate change- it will not formally test banks' capital adequacy, but it is expected that climate-change risks will eventually feed into prudential capital requirements across Europe.

BdF will run exploratory 30-year climate-change scenarios - they will use their own data for this under a 'bottom-up' approach, and results are expected to be available in April 2021.

**BNM**

**July**

BNM stated the need to integrate climate risk within macroeconomic and financial stability but no approach has been developed yet.

**NGFS**

**September**

The NGFS published *Overview of Environmental Risk Analysis by Financial Institutions* and accompanying case studies.

**Key**

- Supra-national body
- Non-AP national regulator
- AP national regulator



# Climate-related risk stress testing



While the 'why' for understanding, managing, and disclosing climate-related risks is clear, the 'how' still presents a significant challenge.

Carbon footprint analysis, Environment, Social, and Governance (ESG) heatmaps, and policies such as exiting carbon-intensive sectors are examples of current practice for managing climate-related risks at financial institutions. Insurance firms are perhaps the most advanced within the industry, leaning on their experience with modelling against long time horizons (taking into account life spans, natural disasters, etc.). Many non-financial actors have also put forward methodologies for understanding, modelling, and managing climate-related risks that can be adapted for the financial sector. Approaches vary – proposals by academics, international organisations, climate scientists, or non-governmental organisations (NGO) all have different strengths and weaknesses.

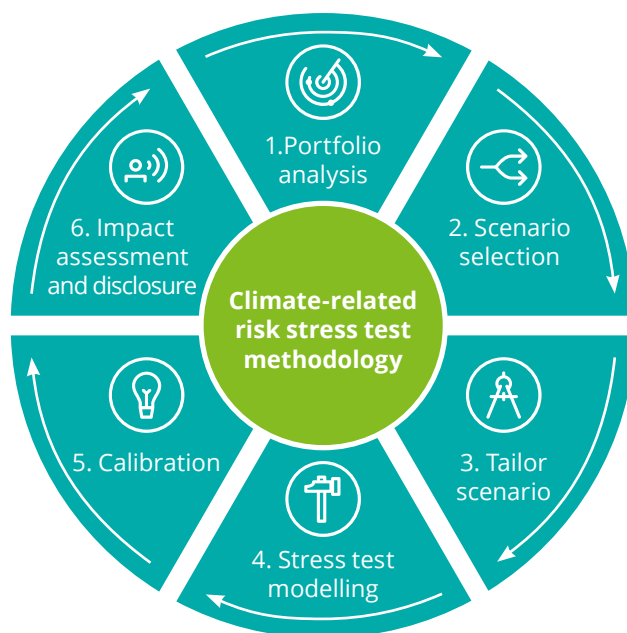
However, issues such as modelling against long time horizons, data poverty, and the complex interplay between transition and physical risks mean that climate-related impacts cannot currently be modelled in their entirety with an acceptable degree

of confidence. As such, there is no singular 'off-the-shelf' framework or industry standard that financial institutions can easily adopt.

Regardless of the challenges, this space has been anything but static. While the breadth of options for climate-related risk management is wide, and supervisory approaches will certainly vary by jurisdiction, one common thread among regulators is the push for financial institutions to develop climate-related risk stress-testing capabilities.

Given the messaging from regulators at home and abroad, it is likely that climate-related risk stress testing will be among the first requirements from many Asia Pacific regulators within the wider realm of climate-related risk management. In the coming year, it will be important for financial institutions to improve their capabilities in this area. Financial firms need to be able to leverage their current macroeconomic and financial stress testing frameworks and experience to integrate a climate-related risk component to make climate risk stress tests coherent with their existing methodologies. The below approach may be useful for firms looking to undertake this integration process.

**Figure 3: Climate-related risk stress test methodology<sup>15</sup>**



## Macroeconomic stress testing

Stress tests analyse the impact of future hypothetical macroeconomic scenarios. A typical stress test usually includes a scenario, an overarching narrative, and a set of models to evaluate performance considering a range of risks under stress. A firm will usually produce both a qualitative and quantitative impact assessment of the outcomes of the stress test as well as commentary on any remediation or strategic responses that should be taken by senior management.

A stress test can involve a top-down analysis (portfolio level assessment) that is reinforced by a bottom-up analysis (counterparty-level assessment). A stress test may also use only one

of the two types of analysis (typically the latter, i.e. bottom-up exercise) based on the data available to the firm. Stress testing exercise outcomes have become essential tools – they inform both a firm’s senior management and regulators about the firm’s resilience to a range of stresses as well as any potential systemic effects either locally or globally.

Current stress test exercises have a time horizon of three to five years and cover a variety of risks - examples include credit, market, securitisation, sovereign, net interest income, operational and conduct, forbearance - under baseline, adverse, and severely adverse scenarios.

# 1

## Portfolio analysis

Portfolio analysis is a crucial first step to building a climate-related risk stress test.

As is discussed in more detail below, the data, time, and resource requirements to undertake a climate-related risk stress test are more onerous than normal macroeconomic stress tests. It is therefore important for financial firms to make strategic decisions upfront about what portfolios they wish to stress and which sectors within those portfolios are at most risk to the impacts of climate change. As with normal macroeconomic stress testing, it is likely that regulators (and in particular those regulators from developed economies) will provide some scenarios and data to be used commonly across firms, but it remains the expectation that firms will create their own stress scenarios that are most relevant for their respective businesses.

When undertaking a portfolio analysis for climate-related risk stress testing, at minimum the following three steps should be undertaken:

- **Sector analysis:** Review the existing portfolio asset allocation among defined sectors and sub-sectors. Since climate-related risk stress tests will involve combining macroeconomic data and potentially the use of models developed by the scientific community, the NGFS recommends using commonly accepted classifications like NACE (Nomenclature des Activités Économiques dans la Communauté Européenne), SIC (Standard Industry Classification) and NAICS (North American Industry Classification System) codes to denominate sectors.<sup>16</sup> From this analysis, firms will want to identify sectors of primary concern within the portfolio under stress. Firms should start by looking at carbon-intensive industries that may feel first-order impacts from climate change. For example, coal-fired energy generation or extractive industries can be impacted directly by transition risk from changes in government policy, while real estate holdings may be directly impacted by physical risk from increased extreme weather events. Then, sectors with second-order impacts can be identified – these are sectors which may not feel the direct impacts of climate change but will be impacted by any knock-on effects.

- Geographic distribution:** Discerning where assets are located and in what proportion of the total portfolio will help both to prioritise sectors and give a fuller understanding of the portfolio's exposure to climate-related risk. Detailed geographic analysis will also help to illuminate the exposure caused by knock-on effects. For example, automotive companies in Asia Pacific may be headquartered in developed economies and therefore face low transition risk in their home jurisdiction as these economies may be judged less likely to suddenly shift public policy without warning. However, this same sector may also have many suppliers located in low-lying coastal areas of less developed economies that are prone to flooding, thereby exposing the automotive sector supply chain to a high amount of physical risk. As Asia Pacific will face outside physical impacts from climate change and has a wide mix of economies that are decarbonising at varying rates, this is a particularly critical step for firms in our region.
  - Time horizons:** A maturity analysis of the portfolio is fundamental to choosing the horizon of the climate-related risk stress testing as firms will have to reconcile the longer time horizons of climate models with the likely much shorter horizons of their portfolios. It should be noted that the sectors that have longer time horizons as part of their operating model may be better suited to climate risk-related assessment. These sector-specific time horizons already expose the portfolio to a certain amount of climate-related risk due to their long maturity and should be considered when prioritising sectors for stress testing.
- There are many different ways to undertake the above portfolio analysis - the NGFS offers some guidance to consider sources of climate-related risks that can be used to start.

**Figure 4: Sources of environmental risks** <sup>17</sup>

Physical Risks	Sub-categories/examples
<b>Extreme weather events</b>	Tropical cyclones/typhoons, floods, winter storms, heat waves, droughts, wildfires, hailstorms
<b>Ecosystem pollution</b>	Soil pollution and degradation, air pollution, water pollution, marine pollution, environmental accidents
<b>Sea-level rise</b>	Chronic sea-level rise or sea surges
<b>Water scarcity</b>	Drought or insufficient supply of water
<b>Deforestation/desertification</b>	Deforestation caused extinction of species, changes to climatic conditions, desertification, and displacement of populations
Transition Risks	Sub-categories/examples
<b>Public policy change</b>	Energy transition policies, pollution control regulations, resource conservation regulations
<b>Technological changes</b>	Clean energy technologies, energy saving technologies, clean transportation, and other green technologies
<b>Shifting sentiment</b>	Changes in consumer preference for certain products, changes in investor sentiment on certain asset classes
<b>Disruptive business models</b>	New ways to run businesses that can rapidly gain market shares from traditional businesses (e.g., virtual meetings that significantly reduce business travels; vertical farming that challenges traditional farming)

# 2

## Scenario selection

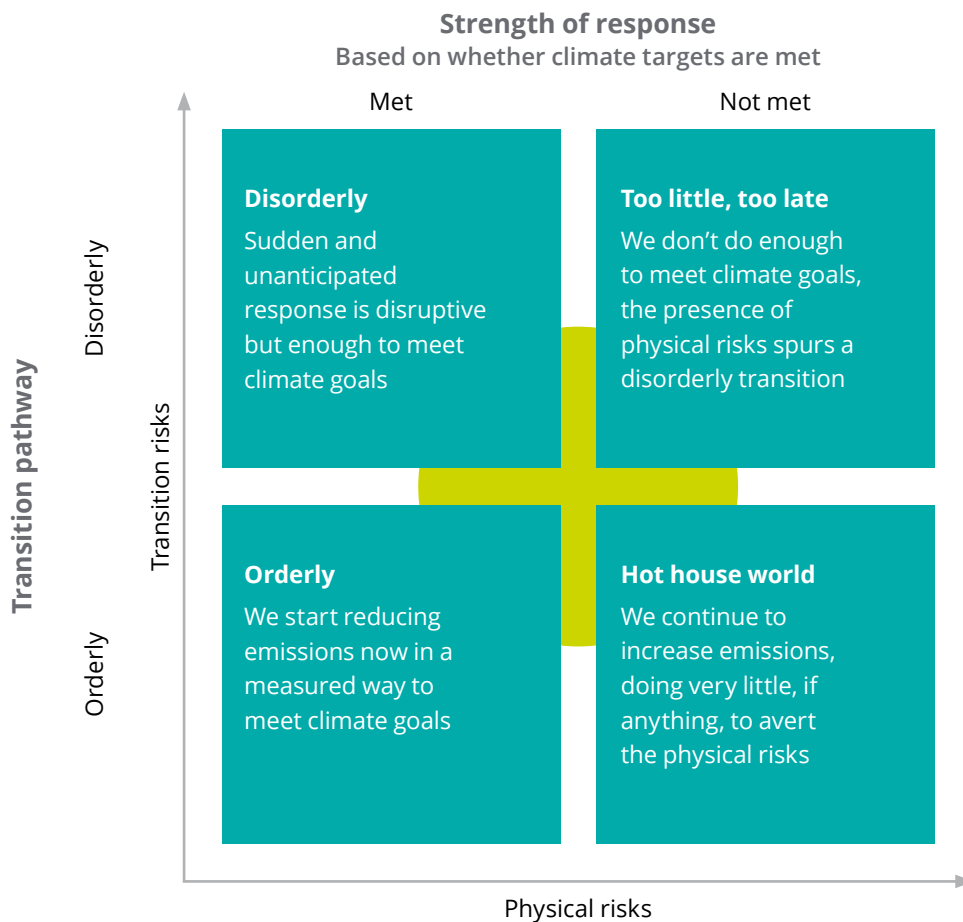
### What are climate scenarios?

Like with normal macroeconomic stress testing, climate-related risk analysis is underpinned by scenarios. These are qualitative narratives that describe the complex relationships between climate-related risks and their impact on the environment, economy, and society. Multiple scenarios should be used to describe different states of 'what-if' in order to thoroughly stress the chosen portfolio.

The NGFS highlights two key factors to describe the impact of climate risks on the economy and the financial system:

- **The level of mitigation of climate risks,** representing the level of action taken at a society level to reduce greenhouse gas emissions given a climate target.
- **Whether the transition occurs in an orderly or disorderly way,** when climate targets are met or not and the impact of future actions.

Figure 5: High-level NGFS scenarios recommendations for central banks and supervisors <sup>18</sup>





Scenarios should also address both physical and transition risks:

- **Physical risk narratives** focus on changes to climate-related extreme weather events to address the intensity and frequency of these events and provide a plausible future overview of their impacts.
- **Transition risk narratives** describe different pathways for the evolution of carbon-intensive economic activities, such as energy generation, industrial production, and transportation. Policy, technology, market, and reputational risks are examples of transition risks. Assumptions underpinning transition risk scenarios are designed to be consistent with the expected responses to pre-determined levels of warming.

Scenarios are usually forward-looking and **temperature-based**, in that they imagine worlds where warming happens within different temperature thresholds such as 1.5°C, 2°C, or even 3°C. Within these temperature thresholds, multiple pathways may be explored to arrive at said thresholds. Scenarios then make use of mathematical models designed to simulate outcomes within our complex and interconnected economic system, accounting not just for both physical and transition risks but energy usage, land use, carbon emission, and so on within these different pathways.

While physical and transition risks are usually modelled separately, a climate scenario will often describe the interaction between the two. For example, the manifestation of extreme weather events can heighten legal and regulatory restrictions on carbon-intensive activities, thereby affecting the rate of economic transition to low-carbon activities. Conversely, in a scenario that expects to see early, coordinated, and meaningful public policy action, physical risks will be lower over the longer term.

Moreover, it should be acknowledged that not all scenarios lead to negative outcomes for firms. A firm looking to understand the impact of a strategic decision to increase exposure to renewable energy sources – a sector that scientists and policy-makers agree must grow significantly if we are to avert the most devastating impacts of climate change – may find differing upsides in different scenarios.

### Reference scenarios – scientific and academic scenarios

Firms may decide to build their own climate scenarios from scratch, but the richest data is found in the temperature-based reference scenarios created by the scientific and academic communities that can be adapted for more specific purposes. As most reference scenarios are not created for financial risk assessment, they will need to be modified for the purpose.

Some advantages to using scenarios developed by the scientific community include being able to take advantage of the modelling expertise of leading research institutions, and by using similar narratives/ drivers, there is also a level of comparability between analysis done by banks and those done by corporates in other sectors.

Commonly used reference scenarios, such as those published by the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA), set out a comprehensive series of future pathways. They are based on modelling techniques which convert a set of assumptions, inputs, and constraints into outputs or scenario parameters. Figure 6 describes several commonly used reference scenarios developed by the scientific community, international organisations, and NGOs.

Figure 6: Overview of commonly used reference scenarios

Organisation	Description	Relevant research publications	Publication year	Description of the work	Sector Coverage	Type of risks addressed
Intergovernmental Panel on Climate Change (IPCC)	A scientific and intergovernmental body under the governance of the United Nations	Fifth Assessment Report (AR5)	2014	The AR5 describes four Representative Concentration pathways (called: <b>RCP2.6, RCP4.5, RCP6.0 and RCP8.5</b> ) and greenhouse gas concentration trajectories.	All sectors	Transition and physical risks
		Special Report, Global Warming of 1.5°C	2018	The Special Report on Global Warming describes the implications of a global warming of 1.5°C. The report explores mitigation, adaptation pathways for a world compatible with a global warming limited to 1.5°C. <b>The scenario pathways are called SSPs (socio-economic pathways)</b> of which there are five different pathways (SSP 1-5).		
Potsdam Institute for Climate Impact Research	A non-profit organisation that researches climate change	Scientific research:			All sectors	Transition and physical risks
		Challenges in producing policy-relevant global scenarios of biodiversity and ecosystem services	2020	Uses global land-use and climate projections to simulate possible future impacts on terrestrial biodiversity and ecosystem services using a variety of models and a range of harmonised metrics.		
		Do Benefits from Dynamic Tariffing Rise? Welfare Effects of Real-Time Retail Pricing Under Carbon Taxation and Variable Renewable Electricity Supply	2019	Analyses the gross welfare gains from real-time retail pricing in electricity markets where carbon taxation induces investment in variable renewable technologies.		
	Technology learning and diffusion at the global and local scales: A modelling exercise in the REMIND model	2020	Addresses how multi-level learning affects technology diffusion and the regional costs of mitigation policies, alternative variants of multi-scale learning are implemented and calibrated to one set of regional-specific cost data.			

Organisation	Description	Relevant research publications	Publication year	Description of the work	Sector Coverage	Type of risks addressed
<b>International Energy Agency (IEA)</b>	A body under the Organisation for Economic Co-operation and Development (OECD) governance, specialised in providing scientific analysis for the energy markets	Renewables 2019	2019	The report analyses and forecasts developments in renewable energy technology based on global trends (from 2019 to 2024).	Energy sector	Transition risks
		World Energy Model	2019	The published scenarios describe future pathways for the global energy system under different assumptions. The pathways range from 2°C to 6°C. Example scenarios: the Sustainable Development Scenario, the Stated Policies scenario, etc.		
<b>International Institute for Applied Systems Analysis (IIASA)</b>	An independent research institute that focuses on policy issues that require multilateral and multidisciplinary solutions	Integrated Assessment Framework (IAM)  The IIASA was also a major contributor to the IPCC reports	2011 onwards	The IIASA developed an IAM framework that combined RCP and SSPs for an integrated approach and improved assessment of climate change vulnerabilities, adaptation, and mitigation needs.  The overarching aim of their work is to integrate, in a consistent and timely manner, the work of communities, whose research corresponds to the three main working groups of the IPCC.  As well, the IIASA also hosts a database of many different climate scenarios for public use, including those developed by the NGFS.	All sectors	Transition and physical risks

**Reference scenarios – financial services specific scenarios**

As stated previously, reference scenarios will need to be tailored for both the financial industry as well as a firm specifically. In light of this, the NGFS, along with a consortium of leading research institutions, has developed three reference scenarios specifically for the financial sector. They have also issued guidance on how financial supervisors could similarly create scenarios for use by financial firms.<sup>20</sup> This does not mean that financial firms must or should use only NGFS scenarios. Rather, the NGFS scenarios are a useful tool for financial institutions to either use in their own exercises or to learn how to tailor generic scenarios for the financial sector.

The NGFS scenarios draw on the work done by the IPCC in the *Special Report, Global Warming of 1.5°C* and uses the SSP 2 “Middle of the road” development pathway,

which outlines a world where social, economic, and technological trends remain roughly the same as historical patterns. This creates an overarching storyline, set of assumptions, and dataset that can be used to model different transition pathways. The NGFS scenarios imagine three types of transitions -

- 'An orderly transition',
- 'A disorderly transition', and
- 'A 'hot house world' scenario'.<sup>21</sup>

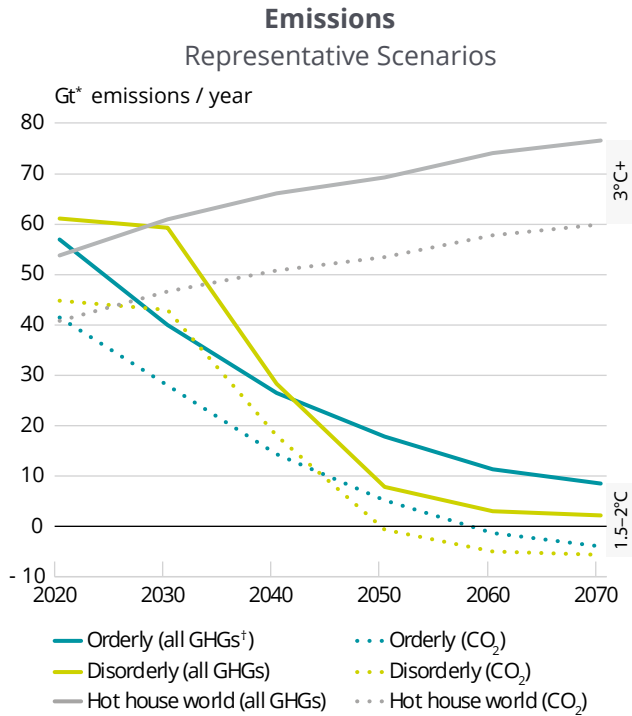
Within these three main transition type scenarios the NGFS has created five alternate scenarios that adjust parameters slightly to allow for more detailed modelling.

The first iteration of the NGFS scenarios was published in June 2020, with an update expected in the final quarter of 2020.<sup>22</sup>

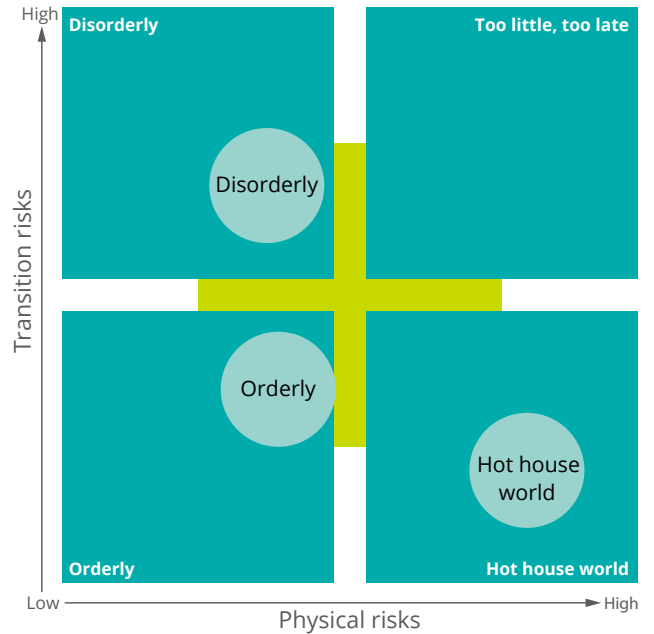
**Figure 7: NGFS reference scenarios for the financial sector** <sup>23</sup>

An orderly transition	A disorderly transition	A 'hot house world' scenario
<ul style="list-style-type: none"> <li>• <b>Orderly transition;</b> immediate action to reduce emissions consistent with Paris Agreement</li> <li>• Emissions price introduced in 2020</li> <li>• Warming below 2°C</li> <li>• Full availability of carbon dioxide removal (CDR) technologies</li> <li>• Net-zero CO<sub>2</sub> emissions between 2050 and 2070</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Disorderly transition;</b> The representative challenging pathway to meeting the Paris Agreement targets</li> <li>• Nationally Determined Contributions (NDCs) followed until 2030</li> <li>• Emissions price rises after 2030 in order to meet emission reduction commitments</li> <li>• Limited CDR</li> <li>• Net-zero CO<sub>2</sub> emissions must be reached more quickly than orderly scenario</li> </ul>	<ul style="list-style-type: none"> <li>• Only current policies implemented</li> <li>• Paris Agreement goals are not met</li> <li>• No change in emission prices</li> <li>• Substantial physical risks in the medium and long term</li> <li>• Estimated median temperature rise of over 2°C by 2050 and close to 4°C by 2100</li> </ul>
<p><b>Alternate scenarios:</b> 1.5°C with CDR; 2°C with CDR</p>	<p><b>Alternate scenarios:</b> 1.5°C limited CDR; 2°C delay with CDR</p>	<p><b>Alternate scenario:</b> NDCs only</p>

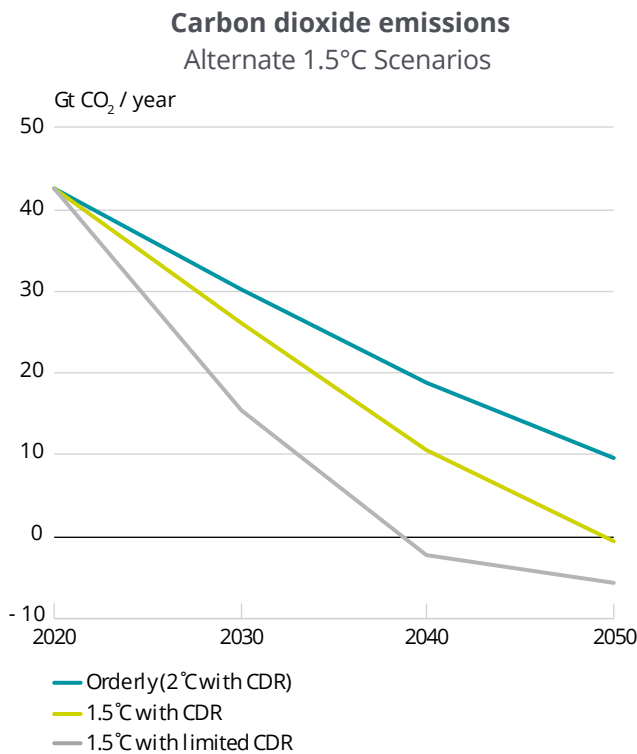
**Figure 8: Main NGFS scenarios** <sup>24</sup>



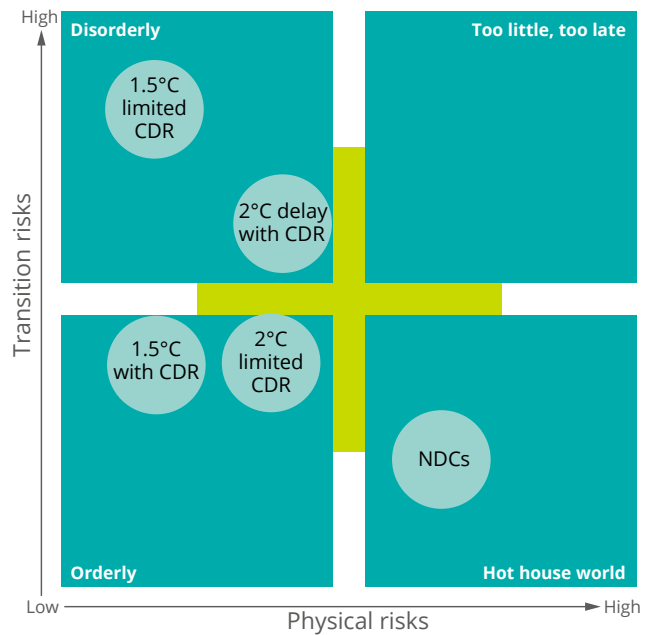
**Mapping of the representative scenarios to the Framework**



**Figure 9: Alternate NGFS scenarios** <sup>25</sup>



**Mapping of the alternate scenarios to the Framework**



\* gigatonne

† green house gas

# 3

## Tailor scenarios

Once reference scenarios have been selected, firms should tailor them to be more relevant to their business activities, with a focus on the sectors that were deemed a priority in the initial portfolio analysis. The aim is to transform the generic reference scenarios into a series of sector-specific narratives for granular analysis of a given portfolio.

Tailoring a scenario begins by identifying how each sector will be affected by climate-related risks and the drivers of these risks to get a full picture of the sector-specific exposure. The next step is to consider how the sector will evolve within the context of the generic scenario that has been chosen – often referred to as 'creating a climate narrative'.

This evolution can be difficult to construct and will require inputs like the influence of demographic, national, and international policy actions as well as

macroeconomic, technology-related, and consumption-related variables. Some of this data may be contained within the source scenario itself but may need to be sourced either from within the institution itself or from publicly available databases. Also, these sector-specific pictures should not be created in isolation – different sectors will, of course, be impacted by climate change in different ways but the overarching generic scenario should be used to ensure coherence for a holistic portfolio stress test.

Once this has been done, firms should map the identified physical and transition risks through different channels on to market, credit, or operational risks so that climate risks are mapped to financial risks.

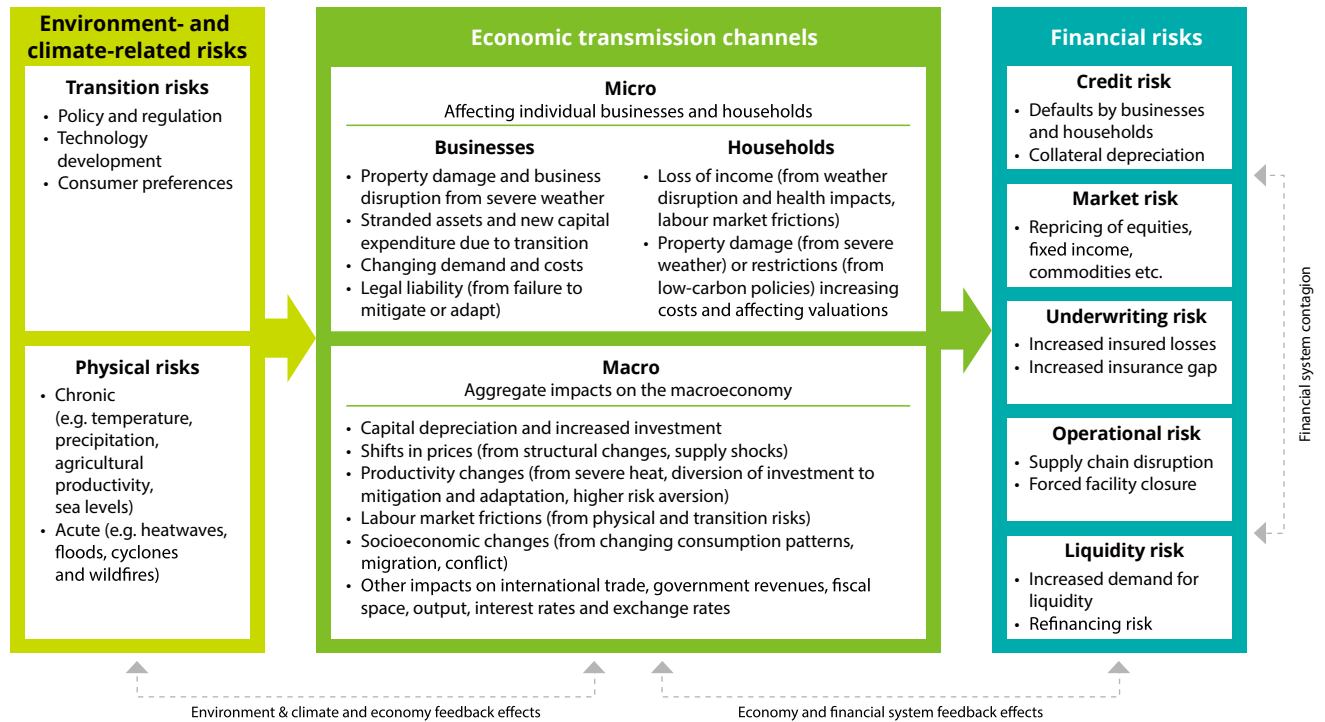
As an illustration, the Federal Financial Supervisory Authority (BaFin), the financial services regulator in Germany, has issued a perspective report, classifying climate-related risks with respect to existing financial risks.

**Figure 10: Overview of climate risks with respect to financial risks** <sup>26</sup>

	Credit risks	Market risks	Operational risks
Physical risks	<ul style="list-style-type: none"> <li>• Re-evaluation of debt capacity</li> <li>• Collateral valuation</li> <li>• Rating downgrades</li> <li>• Impact in loss given default (LGD) and probability of default (PD)</li> </ul>	<ul style="list-style-type: none"> <li>• Rating downgrades and share price losses after disasters and result in productivity decline</li> </ul>	<ul style="list-style-type: none"> <li>• Site closures</li> <li>• Limited banking availability</li> </ul>
Transition risks	<ul style="list-style-type: none"> <li>• Risk transfer impact in rating downgrades</li> <li>• Impact in probability of default (PD) and loss given default (LGD)</li> </ul>	<ul style="list-style-type: none"> <li>• Sudden extreme price fluctuations in assets</li> <li>• Stranded assets</li> <li>• Price increases</li> </ul>	<ul style="list-style-type: none"> <li>• Reputational damage and failure to adapt to sustainable management practices</li> </ul>

The NGFS also provides a list of transmission channels that may prove useful for this mapping.

**Figure 11: Transmission channels for climate-related risks** <sup>27</sup>



**4 Stress test modelling**

Climate-risk stress test modelling can be done by using two different complementary approaches: a top-down macro analysis that is reinforced by a bottom-up micro analysis. The aim is to incorporate shocks at both the portfolio and borrower level to calculate both systematic and idiosyncratic risks, thereby maximising the power of the climate-related risk stress test. While the following describes an ideal situation where both types of analyses would be used, data constraints may make this unfeasible. This point is acknowledged by the NGFS<sup>28</sup> and financial firms should work to understand what analysis can be undertaken with the data available to them.

### Top-down macro analysis

The top-down macro analysis is a portfolio level-assessment that aims to describe the evolution of credit quality under different magnitudes of climate change set out in chosen climate scenarios. Stress scenarios are based on climate-related, macroeconomic, and financial variables that can be attached to different sectors; forecasts of these variables will show transformations in these sectors. This can then be translated to impacts on various risk parameters to understand credit quality against selected climate-related risks in the portfolio being stressed.

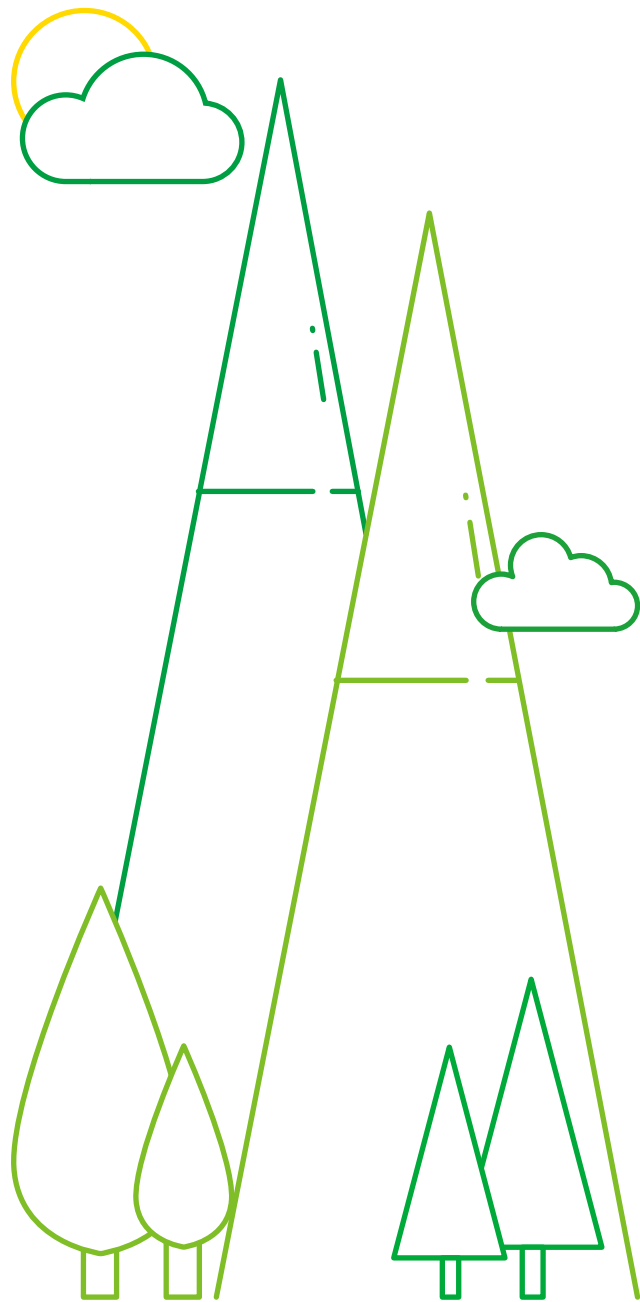
### Bottom-up micro analysis

The top-down macro analysis is balanced by bottom-up micro analysis where firms look at vulnerabilities at the counterparty level. This adds an important level of sensitivity to modelling as each counterparty will respond differently, and at different rates, to climate change. A given portfolio may have a wide number of counterparties with differing levels of data available on which to base this analysis.

There is currently no standard for what proportion of portfolio counterparties need to be assessed at the counterparty level and this requirement (should one come into force) will likely vary across jurisdictions. The NGFS acknowledges the challenge of granular counterparty level data and recommends that regulators first survey firms to understand if they have the necessary access to data and if it is in a format that is workable to carry out this kind of analysis.<sup>29</sup> The UK Prudential Regulation Authority's (PRA) 2021 *Biennial exploratory scenario on the financial risks from climate change* states that "counterparty-level assessment should aim to cover 80% of participants' 'nominal exposure' in the scope of corporate loans".<sup>30</sup> While this is stated in the context of banks, the importance of a counter-party level analysis applies to all type of financial institutions.

### Translation to financial risks

Once the above is completed, analysis should be undertaken to understand the financial impacts of climate-related risks. The transmission mechanism of climate-related risks determines the choice of risk metric; both the transmission mechanism or risk metric may change under different climate scenarios or over time within a single climate scenario.





# Case study on translating physical risk to financial risk from China

For the Asia Pacific regional perspective, research done by a prominent university in China mainland also provides a useful example for financial services firms to use when tailoring their scenarios.<sup>31</sup>

Researchers analysed how climate change may impact the intensity and frequency of typhoons that hit Chinese coastal cities. The study looked at how this increase in physical risk could affect credit risk metrics, specifically the probability of default (PD) and the loss-given-default (LD) of mortgage loans in Chinese coastal cities in order to estimate the percentage of expected loss of the exposure-at-default (EAD).

The researchers first created a disaster loss model, which was used to measure the value of losses from physical property damage, economic impact (e.g., a decline in Gross Domestic Product (GDP) or household income), and financial losses due from natural disasters.

Their **disaster loss model** has four components:

- **Exacerbation module** – looks at how a higher concentration of carbon in the atmosphere affects a typhoon's speed or frequency
- **Hazard module** – assesses the historical distribution, frequency, and intensity of typhoons in a particular area of China
- **Asset exposure module** – finds the geographical distribution and value of assets being stressed
- **Vulnerability module** – finds the correlation between the magnitude of potential damages and the intensity of a typhoon; essentially, how vulnerable to damage a physical asset is. Here the researchers used a damage function curve to understand what degree of property loss occurred because of an increase in the number and severity of typhoons

**PD transmission mechanism** – the researchers then looked at changes to the loan-to-value ratio and household income as the affected variables from typhoons. The rationale for choosing these was that property damage from a typhoon would increase the loan-to-value ratio while at the same time impacts to household income could damage a borrower's ability to repay a loan. Taken together, these could increase the risk that a borrower could default on a loan.

**LGD transmission mechanism** – the researchers noted that the loan-to-value ratio is also a key driver of LGD and that an increase in the loan-to-value ratio also implies that the value of collateral may have decreased and is, therefore, less able to cover loans should the borrower default.

Researchers used the above to calculate the expected loss as a percentage of EAD under a number of different scenarios. Their model showed that “under an extreme scenario (RCP 8.5 with extreme exacerbation effect on typhoons) the expected annual credit loss of mortgage loans could rise nearly threefold in 2050 compared with a baseline scenario that assumes no change”.<sup>32</sup>



# 5

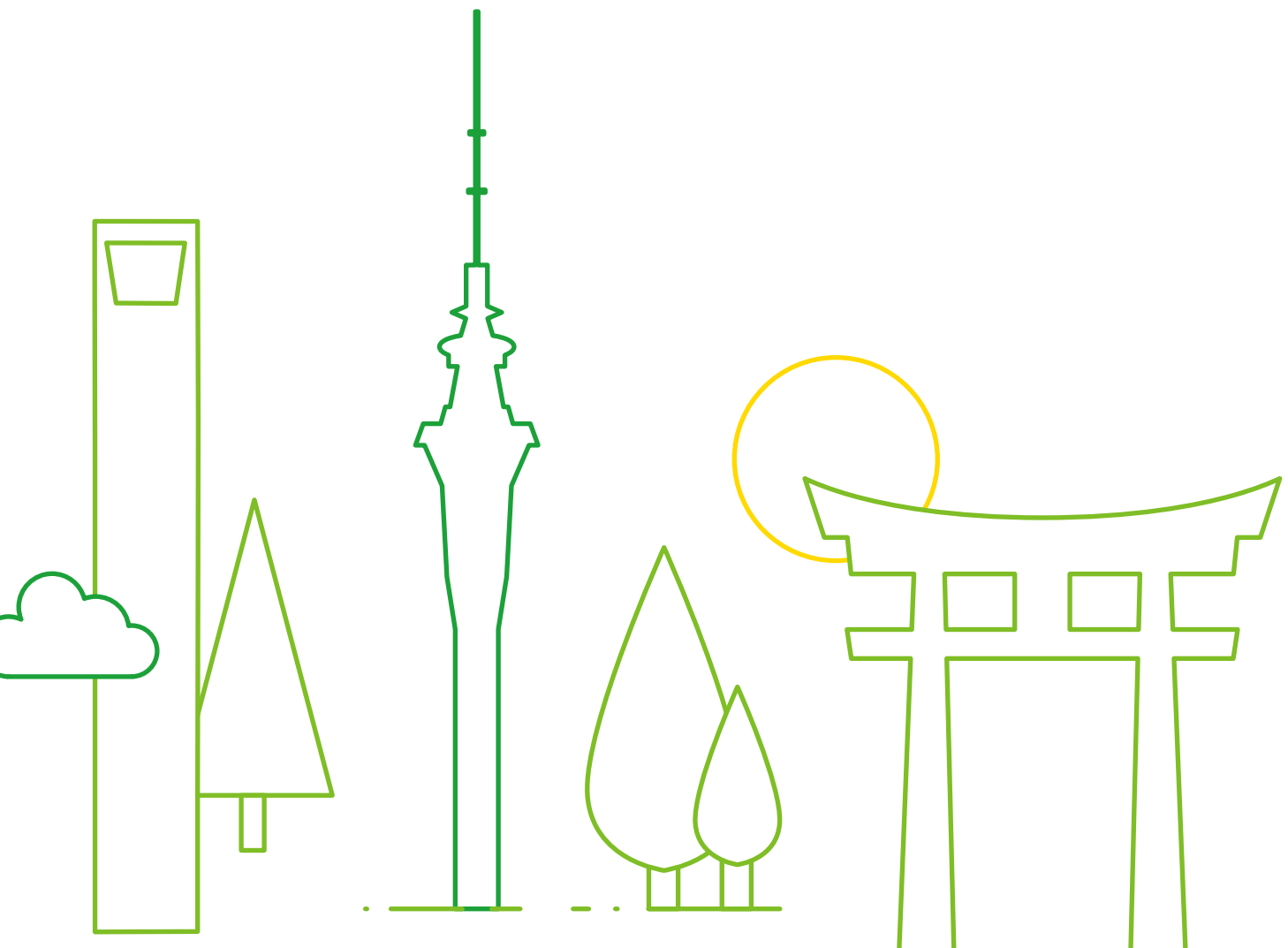
## Calibration

To eliminate overlaps between the top-down and bottom-up analyses and to ensure the coherence of the assumptions that have been made, both the underlying methodology and the final output of a climate-related risk stress test should be challenged through a process called calibration. How a firm undertakes calibration will depend on the internal data sources and expertise available – for example, internal firm sectoral data can be used to validate how said sectors evolve under different climate scenarios, or, expert judgement from economists, sectoral, or climate change experts can be used to adjust assumptions. Where this internal data or expertise may be lacking, external sources should be investigated and, if possible, utilised.

# 6

## Impact assessment and disclosure

After the validation exercise during calibration is completed, the entire climate-related risk stress test exercise should be documented and shared with the Board and senior management as well as subsequently prepared for disclosure to regulators. Firms should also be cognisant of what degree they wish to disclose the climate-related risk stress test processes and results; either publicly through ESG reporting or more closely to external stakeholders such as investors. Firms may wish to strike a balance between more detailed and transparent disclosures, such as those called for by the TCFD, and the fact that undertaking climate-related risk stress testing is an evolving field. The finance and investor relations departments may need to be engaged to help make decisions about public disclosures, but with the understanding that the final decision lies with senior management and the Board.



# Challenges and opportunities





### Climate-specific challenges



#### **Data availability and granularity** **Key Challenges**

At this stage, many jurisdictions face gaps in the availability, quality, and granularity of the data utilised for climate scenario analyses, particularly for transition risks but also in many cases for physical risks. Where datasets do exist, there remain significant challenges. There is uncertainty over how datasets may change even in the near future, as they are updated to reflect new understandings and impacts of climate change. The speed with which datasets can be updated may also cause an issue; regulators with the capacity to update datasets every five years may not match the needs of financial institutions who are accustomed to updating data on a quarterly or semi-annual basis. Furthermore, financial institutions may still face a technical challenge in the transformation of such data to fit into its existing processes and systems.

#### **Key Success Factors**

Where available, financial institutions should work to use common data repositories developed by financial supervisors and other reputable third parties, supplemented with internal risk data. Where these options may be in development or unavailable, firms should start with qualitative analyses to build institutional experience with climate scenario analysis.

## Sectoral variance in risk

### Key Challenges

Models will need to be sophisticated enough to account for the varying impacts of climate change to the many and specific sectors to which financial institutions are exposed. Creditworthiness in some regions and sectors will be vulnerable to drought and wildfire. Other regions and sectors will face different forms of transition risk, some more acute in the near-term, and others to materialise in the long-term. Further, in an economy built on global supply chains and reliant on many national markets, all such risks are interconnected. Models must be balanced to take this interconnectedness into account – while not being so rigidly defined that they cannot be applied to more than one or two sectors.

### Key Success Factors

Scenario analyses need to be supported by physical and transition risk scenarios that are tailored to the business activities and context of each institution. Further, physical and transition risk scenarios should be supported by climate models that incorporate chronic risks, acute risks, factors related to energy systems, and economic implications together with policy, legal, technological, and market responses.

## Extended time horizons for climate-related risk

### Key Challenges

Many financial institutions are accustomed to five-year time horizons at the longest for stress-testing and strategy development. For transition risks in particular, some scenarios are being run that play out through the end of the century. Longer time horizons are required to assess climate risks and build a strategic, forward-looking organisational response; financial institutions may need to challenge entrenched short-term processes and mind-sets in order to do so.

### Key Success Factors

Financial institutions should not let higher levels of uncertainty and lack of familiarity with long-term time horizons paralyse them into inaction. As climate action becomes more pressing from financial risk and regulatory perspectives, firms should ensure that 'tone from the top' and 'tone from above' support long-term thinking across the organisation.

## Organisational challenges



### Consistency and reliability in methodology and process Key Challenges

Firms can expect that the hard work to develop, implement, and refine methodology and process will play out over the course of several years. As such, there is ample opportunity for early errors to compound, which could require an overhaul at a later period.

### Key Success Factors

Financial institutions should be considerate in design and methodology so as to ensure that processes can give a reliable and consistent analysis that does not need to be overhauled for any given assessment. Regulators will play a role in ensuring that methodologies are consistent and can be compared across the industry. Moreover, the processes should be easy to incorporate into financial institutions' internal operations, thereby limiting operational disruption and the additional workload required.

## Climate and modelling expertise

### Key Challenges

Building or adapting data sets to fit the context of the financial institution will require that climate and scientific expertise be brought in. Financial institutions will also need to be able to demonstrate that they understand the data and assumptions underpinning climate risk scenarios both for the regulator and the public in any disclosures that are made.

Talent required by organisations includes the ability to navigate, clean, transform, and perform stochastic modelling of climate drivers and identify relevant transmission channels into the organisations' credit risk parameters. Organisations will also need curious minds able to understand and problem-solve for the limitations of existing climate data.

### Key Success Factors

Financial institutions should seek external climate expertise early and ensure that the knowledge gained is retained within the institution. Some financial institutions have leveraged their research teams to build out internal climate expertise, a viable option for firms with sufficient resources.

In order to build relevant climate scenario analysis expertise to address credit-related impacts, financial firms will need to bring together specialised teams drawing on talent from both the credit risk and sustainability fields. The diverse background of this core team will allow them to identify linkages between climate scenarios and the creditworthiness of their borrowers when assessing sector-level impact on a portfolio. For quite complex scenarios, economic expertise will also be required when building and signing off on a climate scenario – for example, to ensure that assumptions about the outlook for the future state of the economy and trends in public policy or technology are consistent and accurate. Finally, for impact assessments run on individual borrowers, financial firms should seek input from sectoral experts (ex. an automotive industry expert) to weigh in on risk assessment decisions.

## Asia Pacific challenges



### Jurisdictional fragmentation

#### Key Challenges

As discussed, different jurisdictions will have different approaches and timelines as regards regulations surrounding the adoption of climate-related risk analysis. As we have shown, there is a certain amount of global convergence as well as fora where regulators can exchange ideas and best practice – local interpretation of these concepts will certainly lead to a certain amount of fragmentation of approach. This will be compounded in Asia Pacific as firms operating in the region will have to manage multiple jurisdictions and varying requirements.

### Outsize impact to Asia Pacific

#### Key Challenges

As discussed at the beginning of this paper, climate change is likely to have an outsize impact on Asia Pacific resulting in potentially greater climate-related risk; this poses serious challenges for the region's governments, citizens, and business communities. The outsize impact of climate change to the region may be further exacerbated by challenges such as data availability, which will be varied across jurisdictions and subject to differing privacy and/or regulatory regimes, that may result in data gaps specific to our region. Finally, as climate-related stress testing is an emerging field, sharing of best practice and lessons learned may take on a different nature than other subject areas.

### Key Success Factors

While the variety of approaches and expectations of regulators in Asia Pacific to integrating climate-related risk analysis into the wider risk management frameworks will present a challenge, it is also an opportunity. Firms should leverage knowledge gained in jurisdictions both within the region and without to understand and implement best practices.

### Key Success Factors

While climate change and managing climate-related risks may present outsize challenges to firms operating in Asia Pacific, they also present an outsize opportunity. Collaborative efforts to understand the reality of economies in transition provide room for creativity. For example, green development government policy agendas in economies that are both industrialising and transitioning away from carbon will greatly incentivise engagement from the private sector and are an opportunity for financial sector innovation. Such public-private collaboration offers financial firms operating in Asia Pacific a chance to be global leaders in responding to climate change and consequently leaders in best practice for managing climate-related risks in their businesses.

# Conclusion

Climate scientists have long reached consensus on the causes and indeed many of the outcomes of manmade climate change - now banks, insurers, asset owners and managers, as well as financial regulators are joining this same consensus.

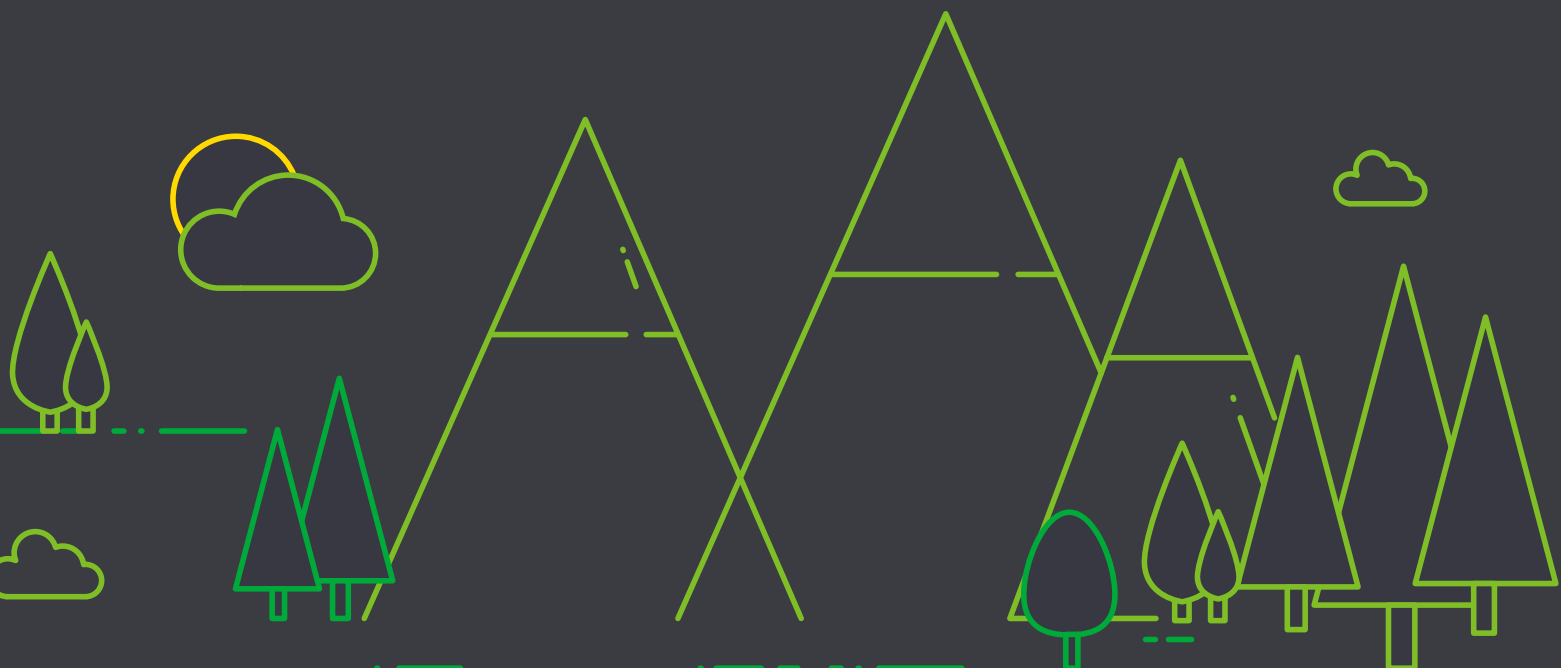
Climate change poses a real risk to both financial institutions and to the stability of the global financial system. This stems both through physical risk from more frequent and severe natural disasters as well as from the need for an economic transition at a vast scale, in which assets could become trapped in traditional, carbon-intensive businesses and rapidly lose value.

Firms should recognise this as urgent - though the impacts of climate change have a longer time horizon and will be felt over the coming century, the need to act in the short-term to mitigate these impacts is imperative. To reduce this risk and to manage new regulatory requirements as well as increased investor expectations, financial institutions should prepare to support their strategic and risk mitigation needs through climate scenario analysis and climate-

related risk stress testing. These measures highlights institutional weaknesses and latent opportunities that can be found in credit or asset portfolios for the purpose of reducing risk and determining future direction.

Preparing for and implementing climate-risk stress testing will not be without challenges. Firms should expect to encounter data that needs to be understood and transformed, balance regulatory requirements, and deal with significant levels of uncertainty over longer time horizons, regarding an issue that necessarily involves stakeholders with diverse perspectives from across the business.

Ultimately, managing climate-related risks should not be seen as simply an exercise in compliance, but rather also as a chance to build value. Those firms that are able to navigate the above challenges successfully will find they are building a more resilient, better equipped business that not only can adapt to climate-related uncertainty, but contribute to the betterment of society through its work in greening the financial system.





# Acronyms used

<b>APRA</b>	– Australian Prudential Regulation Authority
<b>AR5</b>	– Fifth Assessment Report
<b>BaFin</b>	– Federal Financial Supervisory Authority
<b>BNM</b>	– Bank Negara Malaysia
<b>CDR</b>	– Carbon Dioxide Removal
<b>EAD</b>	– Exposure-at-Default
<b>EBA</b>	– European Banking Authority
<b>ESG</b>	– Environment, Social, and Governance
<b>FSB</b>	– Financial Stability Board
<b>GDP</b>	– Gross Domestic Product
<b>GHG</b>	– Greenhouse Gases
<b>Gt</b>	– Gigatonne
<b>HK</b>	– Hong Kong
<b>HKMA</b>	– Hong Kong Monetary Authority
<b>IAM</b>	– Integrated Assessment Framework
<b>IEA</b>	– International Energy Agency
<b>IIASA</b>	– International Institute for Applied Systems Analysis
<b>IPCC</b>	– Intergovernmental Panel on Climate Change
<b>LGD</b>	– Loss Given Default
<b>MAS</b>	– Monetary Authority Singapore
<b>NACE</b>	– Nomenclature des Activités Économiques dans la Communauté Européenne
<b>NAICS</b>	– North American Industry Classification System
<b>NDC</b>	– Nationally Determined Contribution
<b>NGFS</b>	– Network for Greening the Financial System
<b>NGO</b>	– Non-governmental organisation
<b>OECD</b>	– Organisation for Economic Co-operation and Development
<b>PBC</b>	– People's Bank of China
<b>PD</b>	– Probability of Default
<b>PRA</b>	– Prudential Regulation Authority
<b>RCP</b>	– Representative Concentration Pathways
<b>SFC</b>	– Securities and Futures Commission
<b>SIC</b>	– Standard Industry Classification
<b>SSP</b>	– Socio-Economic Pathways
<b>TCFD</b>	– Task force on Climate-Related Financial Disclosures
<b>UK</b>	– United Kingdom
<b>US</b>	– United States
<b>WEF</b>	– World Economic Forum

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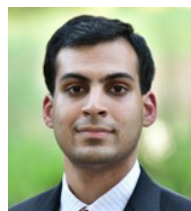


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