Network for Greening the Financial System

Workstream on Scenario Design and Analysis

NGFS Scenarios for central banks and supervisors

November 2023

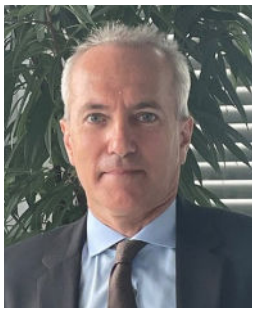
NGFS

Central Banks and Supervisors
Network for Greening the Financial System

Joint foreword



Ravi Menon
Chair of the NGFS



Livio Stracca
Chair of the workstream on "Scenario Design and Analysis"

Climate change poses significant and unprecedented risks to economies and the financial system. Yet, its effects are difficult to assess. Against this backdrop, the NGFS has developed climate scenarios to illustrate what our economies might look like under different assumptions on transition policies and physical risks. These scenarios are a key instrument for central banks, supervisors and private sector players to assess both the macro-financial risks posed by climate change, and the opportunities of timely climate mitigation.

We are delighted to present the fourth vintage of NGFS climate scenarios. Beyond updating the scenario variables to reflect the latest GDP pathways and country-level commitments, the NGFS scenarios have been enriched to better reflect a more disorderly future considering recent developments. In addition, two new scenarios have been introduced: one exploring the consequences of delayed, divergent, and thus overall ineffective climate action, and another Paris-aligned scenario reflecting the need for substantial behavioural changes to avoid the worst impacts of physical risk. Finally, acute physical risk modelling has been enriched by including two more hazards (droughts and heatwaves, in addition to river floods and cyclones) and increasing geographical granularity.

The NGFS scenarios present unique features making them particularly suitable for a wide range of applications. Covering multiple possible climate pathways, the scenarios produces a wide spectrum of variables with a global geographic coverage and a long-term time horizon. They are used by professionals in both the public and private sector to better understand how climate risks impact their organization, financial stability, and the macroeconomy. The scenarios are based on a variety of models that separately but consistently capture climate, macroeconomic and financial contingencies. This is possible thanks to the collaborative effort of several different modelling teams that joined forces with the NGFS and rely on state-of-the-art academic research. As a result, the NGFS scenarios are a global and internally consistent representation of different futures under transition, physical, and macro-financial risks.

We are pleased to reach a further milestone in deepening our understanding of climate impacts, while acknowledging that the journey is not over yet. The first vintage of NGFS climate scenarios was released in 2020, and two more followed in 2021 and 2022. Over time, the NGFS scenarios have become deeper, broader, and richer in terms of modelling tools, output results, risk coverage and geographical scope. The constant updates reflect the innovative nature of climate scenario development, which is at the frontier between climate science, macroeconomic analysis and policy assessment. The NGFS is committed to further enhance the scenarios in the future, incorporating user feedback and the latest scientific advancements, and to remain as an open and collaborative network.

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Acknowledgements

The Network for Greening the Financial System (NGFS) is a group of 127 central banks and supervisors and 20 observers [as of June 13th] committed to sharing best practices, contributing to the development of climate and environment-related risk management in the financial sector and mobilising mainstream finance to support the transition toward a sustainable economy.

The fourth vintage of the NGFS Scenarios is a collaborative effort of the members of the Workstream on Scenarios Design and Analysis and was prepared under the auspices of Livio Stracca (European Central Bank), Chair of the Workstream with support from the NGFS Secretariat. The NGFS Workstream on Scenarios Design and Analysis has been working in partnership with an academic consortium from the Potsdam Institute for Climate Impact Research (PIK), International Institute for Applied Systems Analysis (IIASA), University of Maryland (UMD), Climate Analytics (CA) and the National Institute of Economic and Social Research (NIESR). This work was made possible by grants from Bloomberg Philanthropies and ClimateWorks Foundation.

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Contents

NGFS Scenarios Overview 6

What's new in the NGFS Scenarios 17

Main results of the NGFS Scenarios 22

- Key macrofinancial results 23
- Transition risk 28
- Physical risk 32
- New scenarios in focus 37

Data access and tools 40

What's coming next 47

Key messages

What is new in the NGFS scenarios?

- **The NGFS scenarios have been brought up to date with new economic and climate data, policy commitments, and model versions.** Scenarios have been updated to account for the latest GDP and population pathways and the most recent country-level commitments until March 2023. In addition, the use of Carbon Dioxide Removal (CDR) technologies has been limited due to lower availability of these technologies.

- **Acute physical risk modelling has been enriched by including more hazards and increasing geographical granularity.** The NGFS scenarios cover two new acute physical risk hazards, droughts and heatwaves, in addition to floods and cyclones. Additional channels of transmission to the real economy have been implemented to advance the representation of macroeconomic impacts of the relevant perils. Results are made available at country-level.

- **The NGFS orderly scenarios are now more disorderly, reflecting climate policy delays and the energy crisis** following the war in Ukraine. The scenarios reflect a more pronounced disorderly future considering the delayed implementation of climate policies, persistently high emissions, and the consequences of the war in Ukraine on energy system trajectories.

- **The NGFS scenario framework has been expanded to capture more and less adverse futures.** Two new scenarios have been developed: the "Too-little-too-late" Fragmented World scenario illustrates the adverse consequences of delayed and divergent climate policy ambitions globally, while the "Orderly" Low Demand scenario explores a new Paris-aligned transition driven by substantial behavioral changes. The Divergent Net Zero scenario has been discontinued.

Main results of the NGFS scenarios

- **Reaching global net zero CO_2 emissions by 2050 will require ambitious transition efforts across all sectors of the economy.** The long-term perspective of the NGFS scenarios show that an immediate coordinated transition will be less costly than disorderly or no action in the long run.

- **Limiting the temperature increase to 1.5 °C above pre-industrial levels in an orderly fashion is within reach.** The new Low Demand scenario shows that it will require even greater ambition in the future, with significant reduction in energy demand and changes in consumption patterns. The Net Zero 2050 scenario, which also keeps global warming levels close to the 1.5 °C threshold, requires more intensive efforts than delineated in previous vintages.

- **Physical risks lead to strong negative impacts on GDP** in scenarios in the "Hot house world" and "Too-little-too-late" quadrant. These negative impacts are instead mitigated by (preferably timely) transition efforts in the other scenarios.

NGFS scenarios Overview

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What are the NGFS scenarios?

A shared understanding of how climate change affects the economy can be the basis for global action. The NGFS developed long-term climate scenarios to inform analysis and guide policy worldwide.

The NGFS **climate scenarios** map out how economies might evolve under different assumptions, answering the questions:

What can happen? E.g., if policy ambition diverges and climate change is not mitigated.

What should happen? E.g. to shed light on the benefits of a timely green transition from a macro-financial perspective.

- **The NGFS scenarios have been created to provide a common starting point for analysing the impact of climate risks on the economy and financial system.** They map out **different futures**, depending on how climate change (physical risk), transition policies, technological developments and changes in preferences (transition risk) evolve.

- **The NGFS scenarios explore a range of plausible outcomes.** To reflect the uncertainty inherent to the modeling of climate-related macroeconomic and financial risks (e.g. due to uncertainty of climate change and the transition), the NGFS scenarios use **different models**, and explore **a wide range of scenarios across regions and sectors**.

- **Importantly, the NGFS scenarios are not forecasts.** They are intended to explore the **range of plausible futures** (neither the most probable nor the most desirable) for the assessment of financial risk and to prepare the financial system for the shocks that may arise.

- **The NGFS scenarios present unique features that make them particularly suitable for a wide range of applications.** They produce **internally consistent results** that combine **transition and physical risks and macro-financial developments**, are applicable at the **global level**, and are **freely accessible** through an online public platform. In that regard, they complement existing scenarios such as those available in the IPCC database.

- **While the NGFS Scenarios have been improved in this vintage, one must be fully aware of the uncertainty and limitations of climate and economic modelling.** For instance, tipping points are not represented in the NGFS Scenarios.

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Objectives and framework

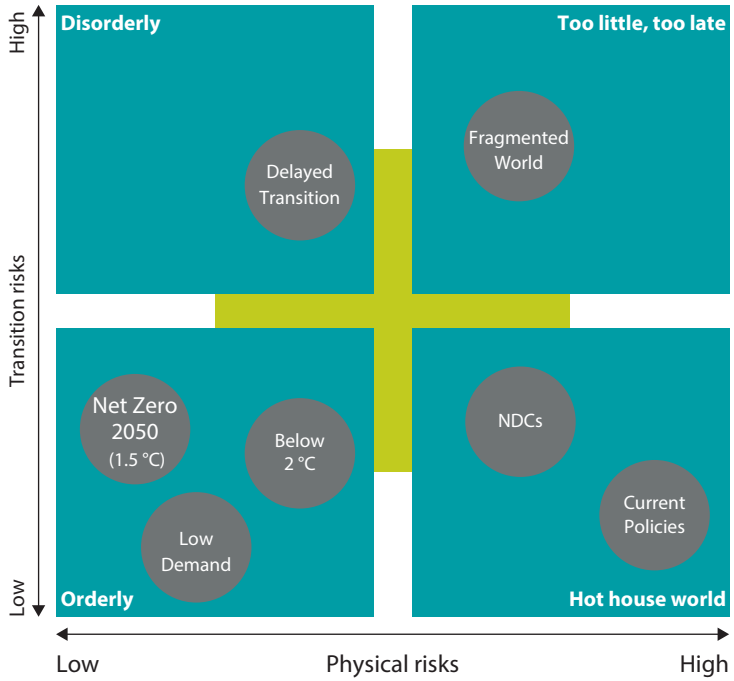
The NGFS scenarios explore the impacts of climate change and the transition with the aim of providing a common reference framework.

The NGFS scenarios explore a set of **seven scenarios** which are consistent with the NGFS framework (see figure) published in the First NGFS Comprehensive Report covering the following dimensions:

- **Orderly** scenarios assume climate policies are introduced early and become gradually more stringent. Both physical and transition risks are relatively subdued.
- **Disorderly** scenarios explore higher transition risks due to policies being delayed or divergent across countries and sectors. For example, (shadow) carbon prices* are typically higher for a given temperature outcome.
- **Hot house world** scenarios assume that some climate policies are implemented in some jurisdictions, but globally efforts are insufficient to halt significant global warming. The scenarios result in severe physical risk including irreversible impacts like sea-level rise.
- **Too-little-too-late** scenarios assume that a late and uncoordinated transition fails to limit physical risks. This quadrant is explored for the first time in this vintage.

Notes: (*) Shadow carbon prices are defined as the marginal abatement cost of an incremental ton of greenhouse gas emissions. Prices are influenced by the stringency of policy as well as how technology costs will evolve.

NGFS scenarios framework in Phase IV



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

Scenario narratives

Each NGFS scenario explores a different set of assumptions for how climate policy, emissions, temperatures and physical risk impacts evolve. Two new scenarios have been designed to capture other potential futures.

Disorderly

Delayed Transition assumes annual emissions do not decrease until 2030. Strong policies are needed to limit warming to below °2C. Negative emissions are limited.

Too-little too-late

Fragmented World assumes a delayed and divergent climate policy response among countries globally, leading to high physical and transition risks. Countries with net zero targets achieve them only partially (80% of the target), while the other countries follow current policies.

NEW

Orderly

Net Zero 2050 limits global warming to 1.5 °C through stringent climate policies and innovation, reaching global net zero CO_2 emissions around 2050.*

Below 2 °C gradually increases the stringency of climate policies, giving a 67% chance of limiting global warming to below 2 °C.

Low Demand assumes that significant behavioural changes – reducing energy demand – in addition to (shadow) carbon price and technology induced efforts, would mitigate pressure on the economic system to reach global net zero CO_2 emissions around 2050.*

NEW

Hot house world

Nationally Determined Contributions (NDCs) includes all pledged targets even if not yet backed up by implemented effective policies.

Current Policies assumes that only currently implemented policies are preserved, leading to high physical risks.

* In these scenarios, some jurisdictions such as the US, EU, UK, Canada, Australia and Japan reach net zero for all GHGs.

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Scenarios at a glance (1/2)

Scenarios are characterised by their overall level of physical and transition risk. This is driven by the level of policy ambition, policy timing, coordination and technology levers.

		Physical risk	Transition risk			
Quadrant	**Scenario**	**End of century warming** *(model averages)*	**Policy reaction**	**Technology change**	**Carbon dioxide removal -**	**Regional policy variation +**
Orderly	Low Demand NEW	1.4 °C (1.6 °C)	Immediate	Fast change	Medium use	Medium variation
	Net Zero 2050	1.4 °C (1.6 °C)	Immediate	Fast change	Medium-high use	Medium variation
	Below 2 °C	1.7 °C (1.8 °C)	Immediate and smooth	Moderate change	Medium use	Low variation
Disorderly	Delayed Transition	1.7 °C (1.8 °C)	Delayed	Slow/Fast change	Medium use	High variation
Hot house world	Nationally Determined Contributions (NDCs)	2.4 °C (2.4 °C)	NDCs	Slow change	Low use	Medium variation
	Current Policies	2.9 °C (2.9 °C)	None – current policies	Slow change	Low use	Low variation
Too-little-too-late	Fragmented World NEW	2.3 °C (2.3 °C)	Delayed and Fragmented	Slow/Fragmented change	Low-medium use	High variation

Colour coding indicates whether the characteristic makes the scenario more or less severe from a macro-financial risk perspective ^

- Lower risk
- Moderate risk
- Higher risk

- The impact of CDR on transition risk is twofold: on the one hand, low levels of CDR imply an increase in transition costs, as reductions in gross emissions should be obtained in a different way; on the other hand, high reliance on CDR is also a risk if the technology does not become more widely available in the coming years.

+ Risks will be higher in the countries and regions that have stronger policy. For example, in Net Zero 2050, various countries and regions reach net zero GHG by 2050, while many others have emission of several Gt of CO_2eq.

^ This assessment is based on expert judgment based on how changing this assumption affects key drivers of physical and transition risk. For example, higher temperatures are correlated with higher impacts on physical assets and the economy. On the transition side economic and financial impacts increase with a) strong, sudden and/or divergent policy, b) fast technological change even if shadow carbon price changes are modest, c) limited availability of carbon dioxide removal meaning the transition must be more abrupt in other parts of the economy, d) stronger policy in those countries and/or regions.

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Scenarios at a glance (2/2)

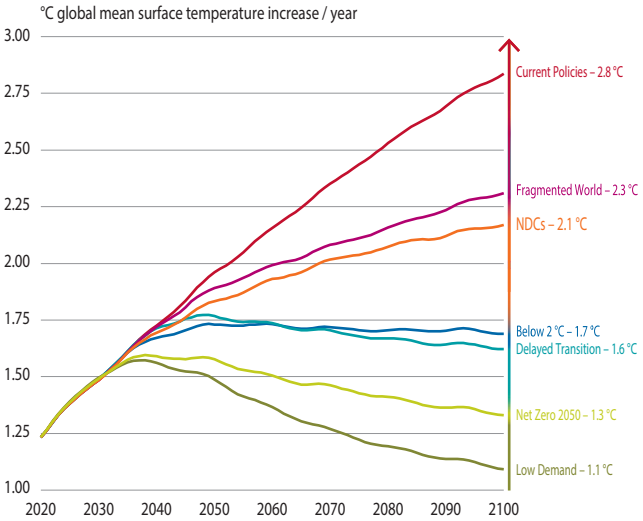
Differences in assumptions across scenarios lead to different temperature pathways, carbon emissions reductions, and (shadow) carbon price developments that allow to reach them.

Carbon emissions and (shadow) carbon price by scenario

In the NGFS scenarios, the main policy lever driving the transition is **a (shadow) carbon price** that (i) represents the marginal cost of abatement of carbon emissions and (ii) is a **proxy for overall climate policy ambition and effectiveness**, accounting for a variety of real-world climate policies (carbon tax, subsidies, environmental standards, etc.).

Temperature Evolution by Scenario

AR6 Surface Temperature (GSAT) increase (50th), MAGICC with REMIND emission inputs

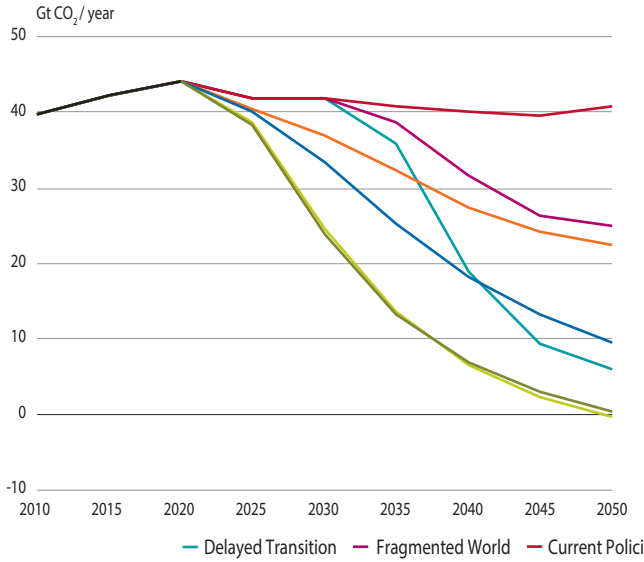


Sources: IIASA NGFS Climate Scenarios Database, MAGICC model (with REMIND emissions inputs). MAGICC provides a range of temperature increase compared to the pre-industrial levels.
The temperature paths displayed here follow the 50th percentile.

N.B. the table on the previous slide shows average temperatures across the three IAMS.

Global Yearly CO_2 Emissions

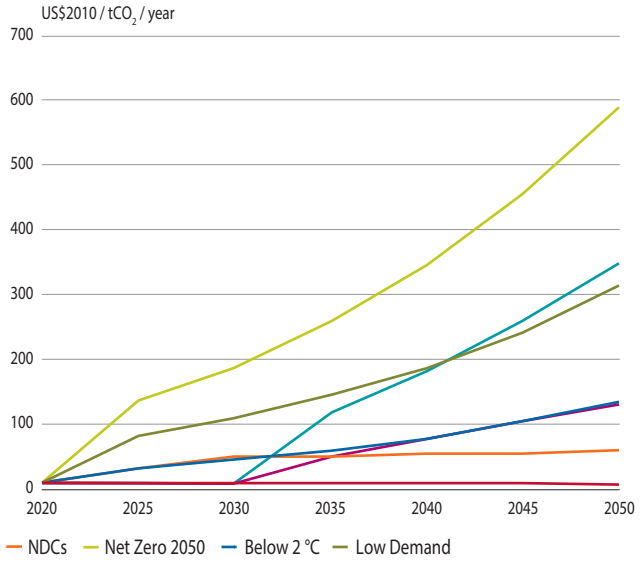
REMIND



Source: IIASA NGFS Climate Scenarios Database, REMIND model. World aggregates mask strong differences across sectors and jurisdictions. Regionally and sectorally granular information is available in the IIASA Portal. End of century warming outcomes shown. 5-year time step data.

Shadow Carbon Price

REMIND



Source: IIASA NGFS Climate Scenarios Database, REMIND model. Shadow carbon prices are a weighted average of regional carbon prices at global level. Regionally and sectorally granular information is available in the IIASA Portal. End of century warming outcomes shown. 5-year time step data.

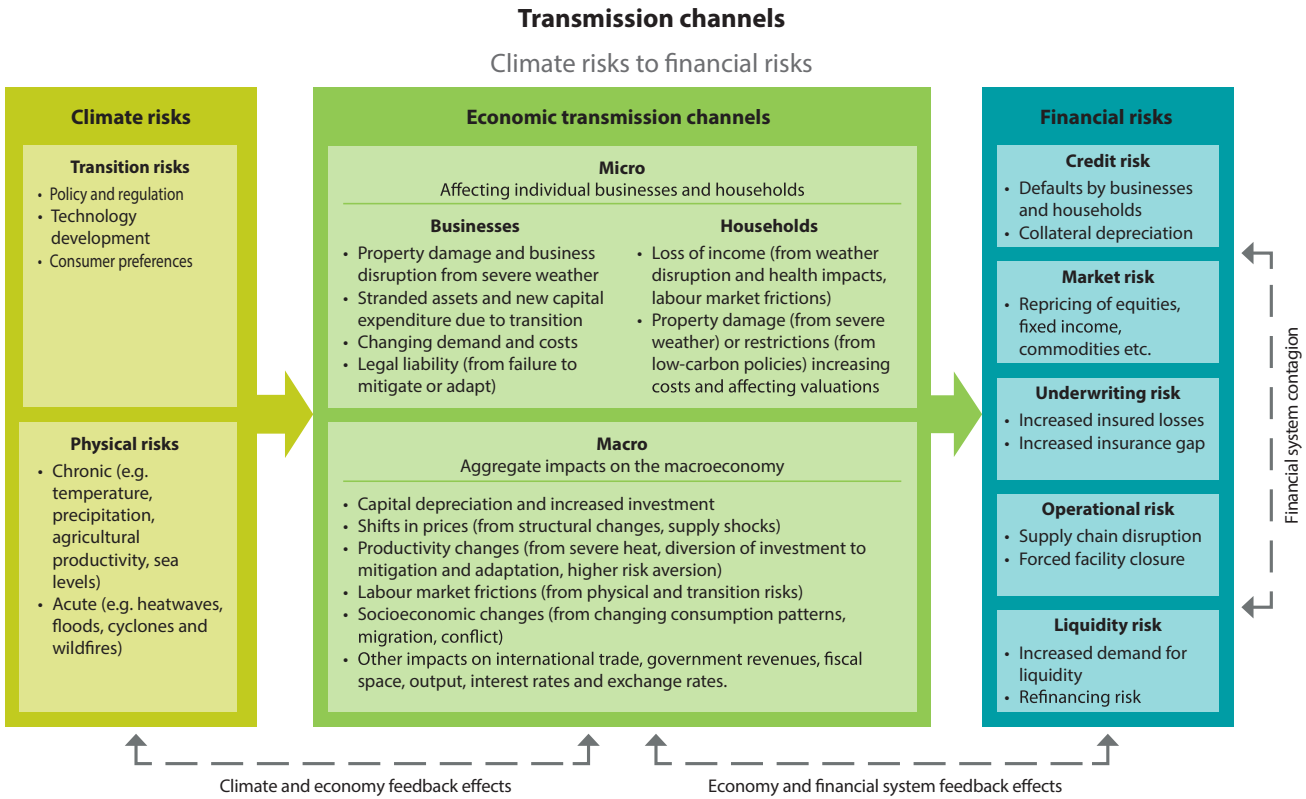
Climate risks

Climate risks could affect the economy and financial system through a range of different transmission channels.

Transition risks will affect the profitability of businesses and wealth of households, creating financial risks for lenders and investors. They will also affect the broader economy through investment, productivity and relative price channels, particularly if the transition leads to stranded assets.

Physical risks affect the economy in two ways.

- **Chronic impacts**, particularly from increased temperatures, sea levels rise and precipitation changes, may affect labor, capital, land and natural capital in specific areas. These changes will require a significant level of investment and adaptation from companies, households and governments.
- **Acute impacts** from extreme weather events can lead to business disruption and damages to property, reduction of agricultural yields or of labour productivity. There is some evidence that with increased warming they could also lead to persistent longer-term impacts on the economy. These events can increase underwriting risks for insurers, possibly leading to lower insurance coverage in some regions, and impair asset values.



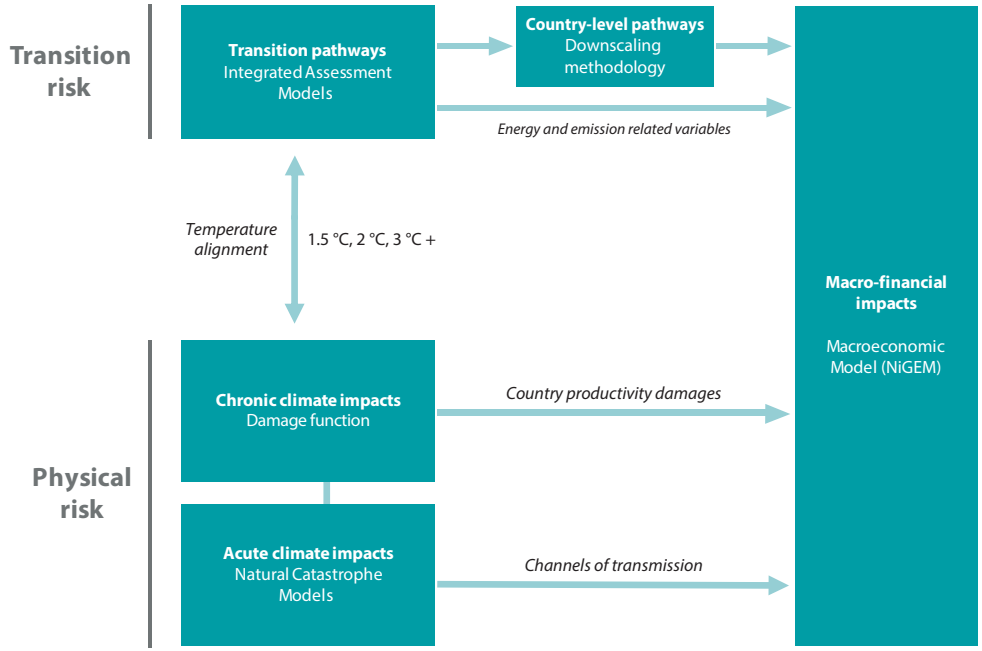
* See slide 19 and 34 on physical risk modelling in the NGFS Scenarios.

NGFS modelling framework

The NGFS scenarios provide a range of data on transition risks, physical risks and economic impacts. This is produced by a suite of models aligned in a coherent way.

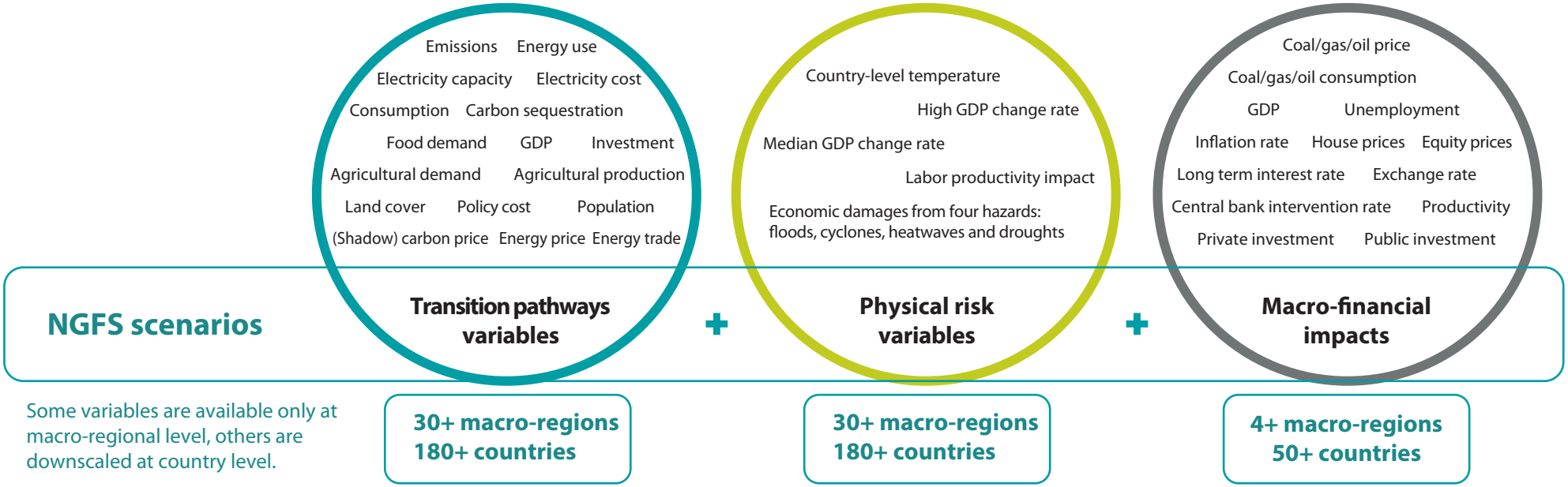
- **Transition risk models** include three Integrated Assessment Models (IAMs), specifically REMIND-MAgPIE, GCAM and MESSAGEix-GLOBIOM, that derive the impacts of different policy ambitions on the energy and transition-relevant sectors (transportation, buildings, etc.), emissions, and land use.
- **Country-level downscaling** is applied to IAMs world regions to provide more granular information on the implications of NGFS Scenarios for 184 countries.
- **Physical risk models** include acute and chronic physical risk models. Acute physical risk is assessed for four hazards at country level with various channels of transmission. Chronic physical risk via an aggregated damage function. Both sets of models project physical risk based on the Global Temperature Paths (GMTs).
- **The macroeconomic modelling** relies on the NiGEM model (a version specifically modified for the purpose of producing the NGFS scenarios), to understand the consequences of transition and physical risk on the key macro-financial fundamentals.

NGFS suite of models approach



NGFS modelling framework

The NGFS scenarios consist of a set of climate-related and macro-financial variables available for each model, scenario and geography.



This slide does not contain the full list of variables and is for illustrative purposes only. The names of the variables do not necessarily correspond to the ones used in the IIASA Portal. The number of countries/regions available varies significantly depending on the variable. Downscaled climate-related and macro-financial variables are available for 180+ and 50+ countries, respectively.

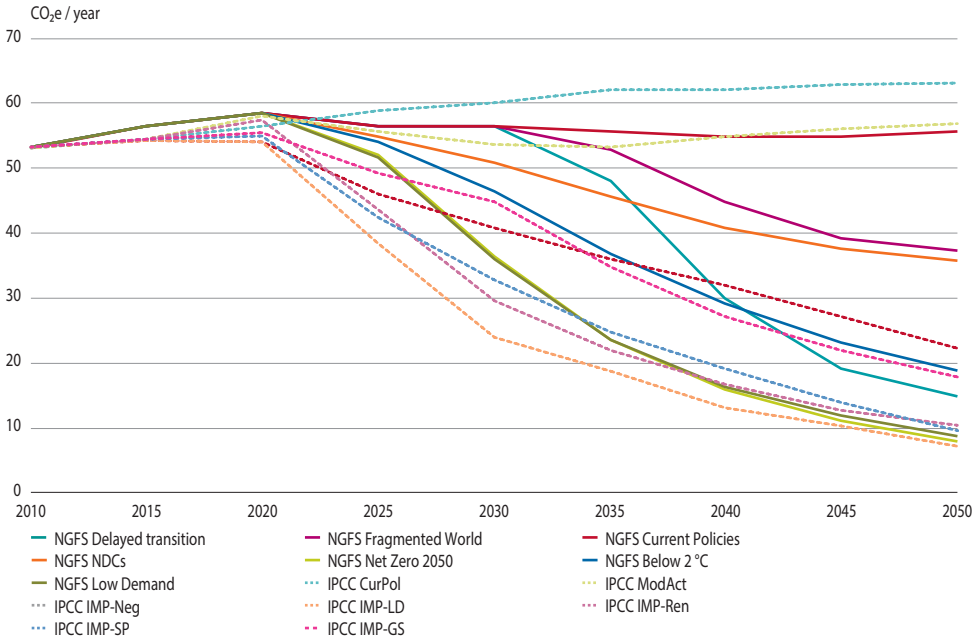
Comparison with IPCC scenarios

The IPCC and the NGFS use Integrated Assessment Models (IAMs) to provide transition pathways for various narratives, with different but consistent results.

- The NGFS scenarios were assessed by the IPPC WG III[1] at the time of AR6 report[2] (2022). They cover a small range of input and model assumptions but have on average higher sectoral and regional granularity than the rest of emission scenarios assessed by WG III.
- As they were developed for risk assessment purposes, the NGFS Scenarios do not always show results equivalent in the IPCC. However, certain scenarios, including the Net Zero 2050 scenarios are well aligned on a number of dimensions.
- The latest vintage of NGFS scenarios (Phase IV), published after the release of AR6 reports, are compared to AR6 WG III Illustrative Mitigation Pathways in the graphs on the right.

NGFS versus IPCC Illustrative Mitigation Pathways

Global GHG Emissions



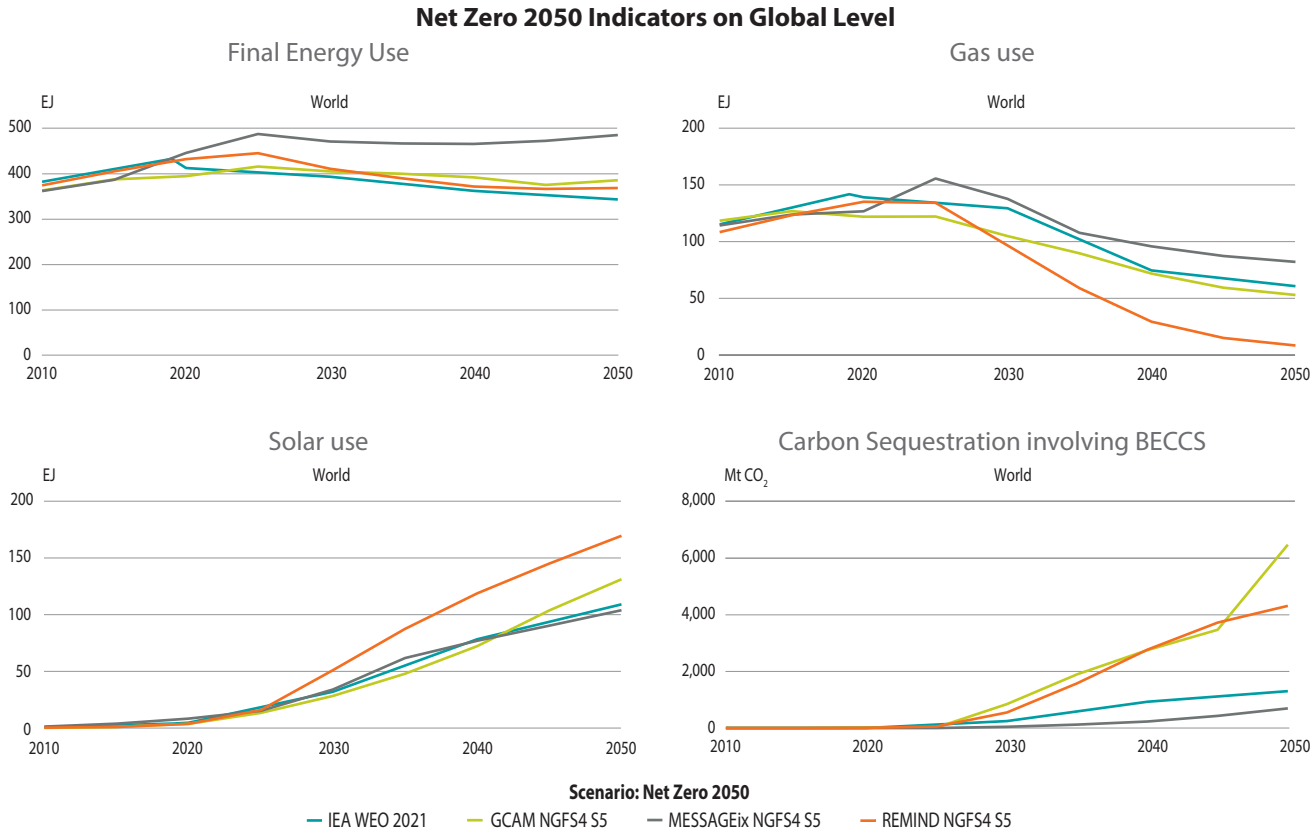
Source: IIASA NGFS Climate Scenarios Database, REMIND model, and IPCC Sixth Assessment Report, Working Group III (2022).

1. WG III is an IPCC Working Group focused on the mitigation of climate change.
2. AR6 report is the Sixth Assessment report published by the IPCC, which is a collection of reports from its various working groups.

Comparison with IEA scenarios

The NGFS and IEA scenarios share commonalities, but also have specificities which make them useful for different applications.

- The NGFS scenarios are mostly used to assess the costs and benefits of the transition for the financial sector, while the IEA scenarios can be used to understand the implications of climate policies.
- Carbon prices are structurally different in the NGFS and IEA scenarios. In the NGFS scenarios, shadow carbon prices are calculated endogenously as a proxy for all kinds of climate policies, whereas in the case of the IEA, the carbon price is set exogenously depending on national carbon pricing and commitments and the degree of emission reductions in each scenario.
- In addition to carbon pricing, the scenarios developed by the IEA separately consider a wide range of other policy measures that can contribute to emission reductions.
- However, NGFS and IEA Net Zero 2050 scenarios are well aligned on a number of dimensions.



1. BECCS (bioenergy with carbon capture and storage) involves capturing and permanently storing CO_2 from processes where biomass is converted into fuels or directly burned to generate energy.

What's new in the NGFS Scenarios

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Updated economic and climate data and revisited assumptions

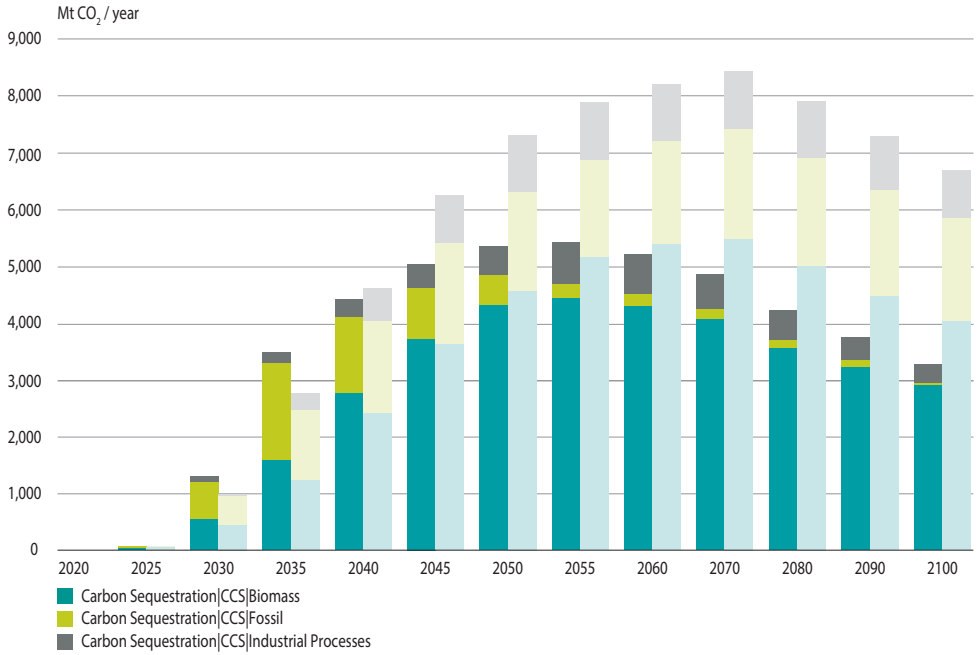
The NGFS scenarios have been brought up to date with latest economic and climate data, policy commitments and model versions. Some technology assumptions have been revisited.

- **Scenarios data** have been updated to reflect:
  - the **new country-level policies** to reach net-zero emissions (e.g. as part of the EU Fit-for-55, the US Inflation Reduction Act, etc.) with a cut-off date of March 2023, contributing to slightly decreasing physical risks;
  - the **latest GDP and population data** using the latest snapshot from the IMF World Economic Outlook 2022;
  - the **current geopolitical context**, including consequences of the war in Ukraine on energy prices, contributing to an overall increase in disorderliness;
  - the **latest trends** in renewable energy technologies (e.g., solar and wind), and key mitigation technologies; for example, capital costs for solar PV will decrease faster according to the new projections.

- **Limits on the availability of Carbon Capture and Storage (CCS) technologies** have been introduced, making the scenarios more adverse due to lower overall availability of these technologies. This is modelled via explicit constraints on the process level such as setting a time-dependent maximum area available for afforestation or maximum yearly bioenergy with CCS potentials. Direct Air Carbon Capture and Storage (DACCS) technologies were switched off in all scenarios, in particular because of the uncertainty with regards to their development.

Carbon Sequestration Phase IV vs Phase III

REMIND, Phase III in transparent coloring



Carbon Dioxide Removal (CDR) involves removing carbon from the atmosphere through increasing forest cover and soil sequestration (land use) or growing crops for bioenergy (bioenergy with carbon capture and storage, BECCS). The speed and timing of the transition depends on the availability and deployment of various forms of carbon dioxide removal, i.e., the long-term storage of carbon in soils, plants and rocks.

Improved modelling of acute physical risks

Acute physical risk modelling was improved to provide economic impact estimates at the country-level, to include more hazards, and to more accurately capture their transmission to the economy.

- **Phase III** NGFS scenarios provided preliminary estimates of global-level impacts of acute risks based on: (i) EM-DAT damage data for historical weather-related disasters; and (ii) estimates of future changes in expected damages from tropical cyclones and riverine floods based on multipliers derived from the CLIMADA model. The scenarios were applied in NiGEM as demand and supply shocks.(*)

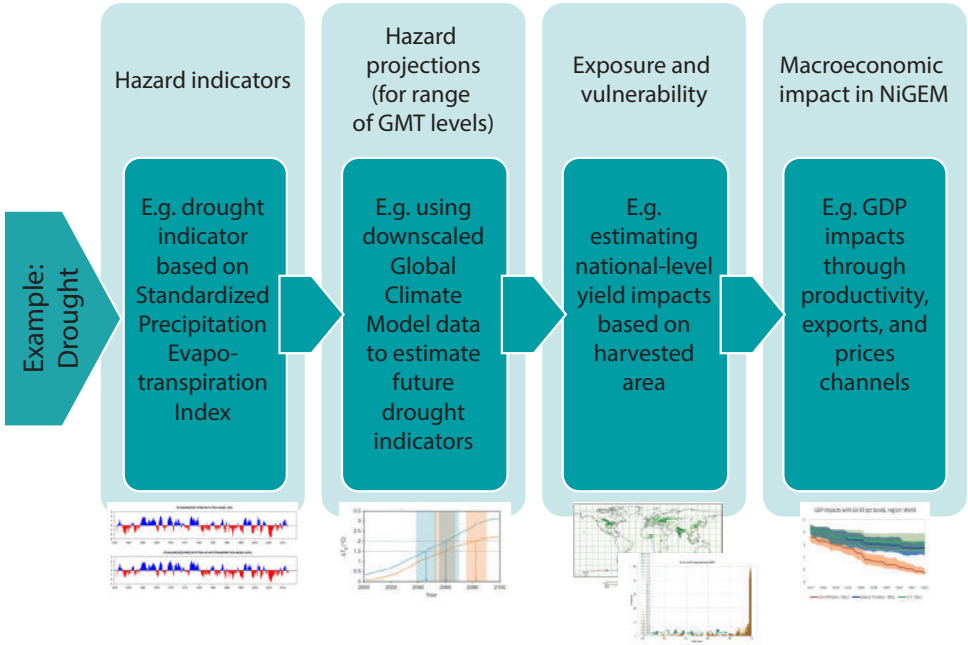
- In **Phase IV**, the modelling was enhanced to include:

  – **Four acute physical risk hazards:** heatwaves and droughts were included, in addition to tropical cyclones and riverine floods, modelled under current and future climate conditions using additional hazard-specific indicators and projection models.

  – **Additional channels of transmission** to the real economy have been implemented for the relevant perils to more accurately capture their macroeconomic impacts.

  – **Country level projections** of GDP losses for all four hazards(**).

  – **A note on the implications of compound risks for physical climate scenario analysis** is published alongside the new scenarios, in the context of the substream efforts to further develop understanding and analysis of physical risks.



Notes: * For both Phase III and IV physical risk is explicitly estimated for 3 quadrants: Orderly, Disorderly and Hot House. The new Too-Little-Too-Late quadrant is not yet estimated but its physical risk impact can be associated to the Hot House (current policies) Scenario.
** For Riverine Floods the asset damages are estimated at macro-region level and country level impacts calculated in NiGEM.

New scenario narratives

The NGFS scenario narratives have been updated and further expanded to capture more adverse disruptions and different potential futures. Two new scenarios have been designed.

Orderly

NEW

***Low Demand*: a new Paris-aligned orderly scenario has been added**

It maps out the challenging path to still reach the +1.5 °C end-of-century warming limit, requiring lower energy demand and stronger behavioral changes to still reach the Paris goals in an orderly way.

Net Zero 2050 (1.5 °C) has shifted upwards in the framework

It illustrates the higher baseline emissions (2021-2025), leading to increased disorderliness with higher physical and transition risks.

Below 2 °C has shifted upwards in the framework

It shows an increased transition risk and slightly lower physical risk. It assumes that countries limit global warming to +2 °C in 2100 (with 66% probability).

Disorderly

Delayed Transition has been updated without a change in its narrative

It assumes annual emissions do not decrease until 2030. Strong policies are needed to limit warming to below 2 °C. Negative emissions are limited.

Hot house world

Nationally Determined Contributions (NDCs) has shifted left in the framework

It foresees that currently pledged conditional NDCs are implemented fully, and respective targets on energy and emissions in 2025 and 2030 are reached in all countries, leading to a slight decrease in long-term physical risk, due to newly announced commitments, but is still high.

Current Policies has shifted left in the framework

It assumes existing climate policies remain in place, but there is no strengthening of their ambition level. This results in a slight decrease in long-term physical risk, due to newly implemented policies, but is still high.

Too-little too-late

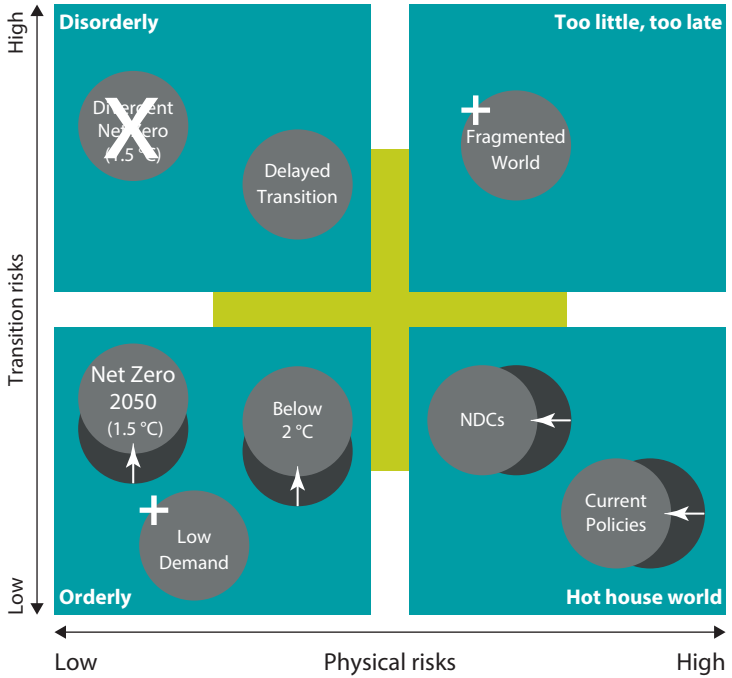
NEW

***Fragmented World*: a new too little, too late scenario has been added**

It explores more adverse impacts as a result of climate policies being implemented in a fragmented manner, both intertemporally and geographically, meaning that countries delay the implementation ("too late"), and then diverge in their mitigation stringency, rendering efforts overall insufficient to reach net zero ("too little").

The Divergent Net Zero (1.5 °C) scenario, previously included in Phase III, has been phased out in this new fourth vintage given the reduced likelihood of a successful uncoordinated transition (this is marked with a cross in the framework).

NGFS scenarios framework: from Phase III to Phase IV



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

Towards a 'more disorderly' orderly transition

The NGFS orderly scenarios are now more disorderly, reflecting climate policy delays and recent developments in energy markets in the current geopolitical context.

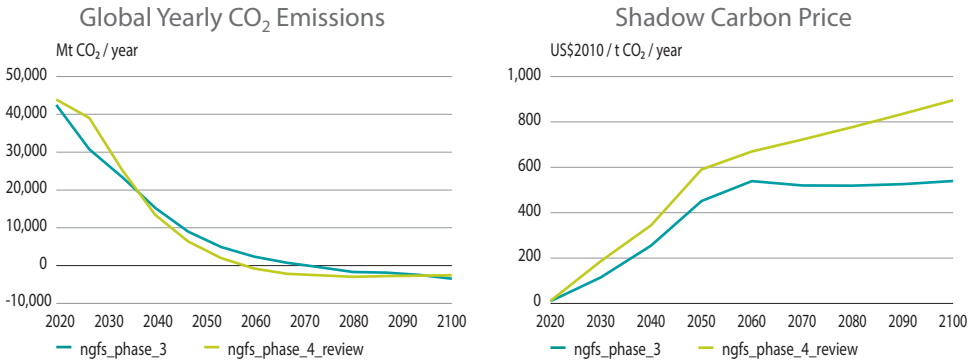
- **Persistently high emission levels,** against the backdrop of an unchanged carbon budget associated with reaching a particular climate goal (e.g., net zero by 2050), **require more rapid and intense emission reductions going forward.**

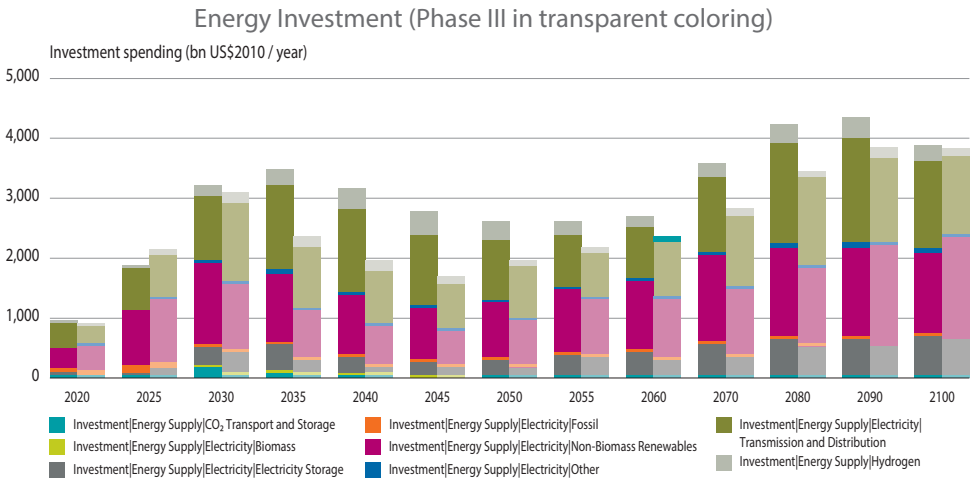
- The need to reach the **same climate goal in a shortening window of time** is reflected in the intensity of the policy efforts and therefore in **higher (shadow) carbon prices**. The global (shadow) carbon price in the NGFS Net Zero by 2050 scenario is higher at every future time step in Phase IV as compared to Phase III.

- Consistently, **energy demand is higher in Phase IV** as compared to Phase III, reflecting updated starting points. The energy mix is also different: fossil fuels play a less important role in the energy mix in Phase IV as compared to Phase III, but only after 2040. The increase in primary energy is instead supported by biomass and non-biomass renewables.

- While **overall energy investments in Phase IV** lag behind what was projected as needed in 2025 under Phase III, they are **much higher starting in 2030**, reflecting the changes in energy demand and energy mix. The strongest increase in investments across phases occurs between 2035 and 2055 and is focused on renewables-based electricity generation, electricity storage, electricity transmission and distribution and hydrogen.

Phase IV vs Phase III (REMIND, Net Zero 2050)





Main results of the NGFS Scenarios

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Main results of the NGFS Scenarios

Key macrofinancial results

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Gross Domestic Product (1/2)

The NGFS scenarios illustrate that an immediate coordinated transition will be less costly than inaction or a disorderly transition in the longer term. Economic impacts differ significantly across scenarios, with recognized uncertainties in the magnitude of the estimates and variations between regions.

- **Transition risk** leads to a negative short-term impact on GDP in the *Net Zero 2050* scenario. However, the cost-saving later on more than offsets these initial losses compared to a *Delayed Transition* or a *Current Policies* scenario.

- **Acute physical risk,** is the most relevant source of risk in the short and long term. Since physical risk is unaffected by mitigation efforts *in the short-run*, acute physical risk is similar across scenarios until 2040, with a strong surge in losses in *Current Policies* thereafter.

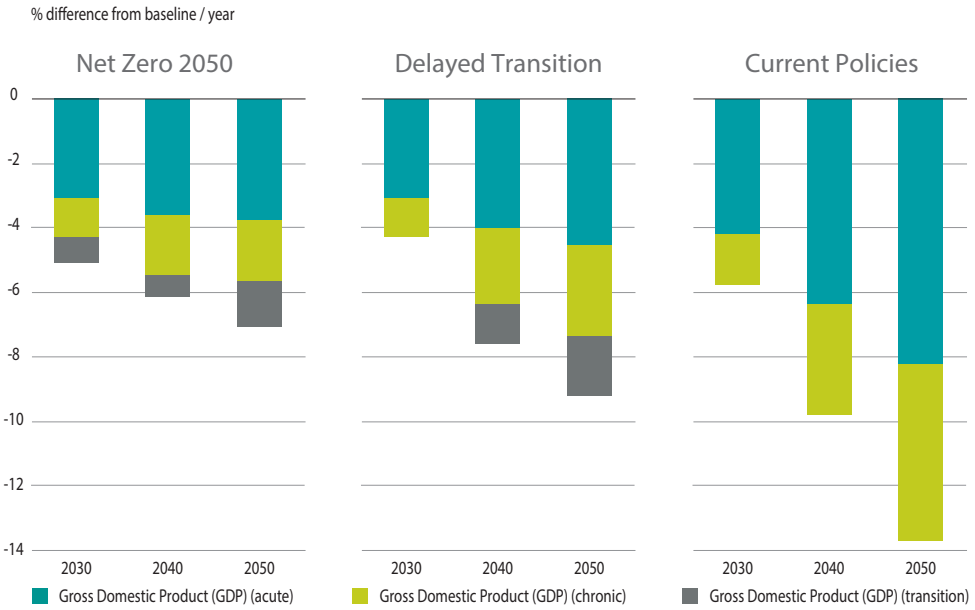
- **Chronic physical risk*** becomes gradually more important over time and causes the largest negative impact on GDP in the *Current Policies* scenario, with associated economic losses in 2050 being almost double than what is implied by *Net Zero 2050* scenario.

- All scenarios show **consistent results** in terms of economic impacts**, with slight differences between models. Impacts on GDP are specified relative to a forecast representing prior trends*** but also incorporating most recent impacts, such as the post-pandemic recovery and the consequences of the Russian war in Ukraine (cut-off date: February 2023).

(*) As in Phase III, the 95th percentile of the temperature distribution is used to estimate chronic and acute physical risks in a current policies scenario.
(**) The estimates of acute and chronic physical risks do not include the effects of reaching climate tipping points, as there is still limited academic literature.
(***) This forecast is therefore a hypothetical baseline scenario with no transition nor physical risk.

Global GDP Impact by Climate Risk Source

NiGEM based on REMIND input



Note: The above figure shows how GDP is impacted across scenarios compared with a hypothetical (and impossible) baseline scenario in which no transition or physical risks occur. This baseline scenario represents a world in which climate change does not occur. Thus, climate change has a negative impact on GDP in every plausible scenario, but the magnitude of the losses differs across them.

Gross Domestic Product (2/2)

The NiGEM model provides economic impacts by country and region, giving estimates of country exposure to transition and physical risks.

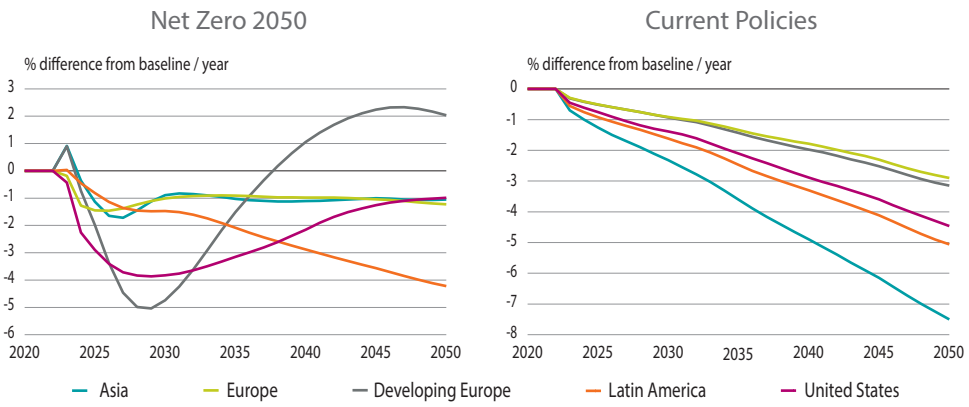
- **In the NGFS scenarios, both transition and physical risk impacts vary across countries according to several factors.**
  - **Transition risk** depends, among others, on the structure of the economy, the dependence on fossil fuels and the trade composition.
  - **Physical risk** depends on the exposure and vulnerability to temperature increase and extreme weather events. In the latter case the channel of transmission of each specific hazard determines the economic impact.

- **GDP Impacts are higher for countries and regions that face higher emissions reduction,** higher (shadow) carbon prices, lower fossil fuel exports or higher physical risk damages from increased temperatures and extreme weather events.

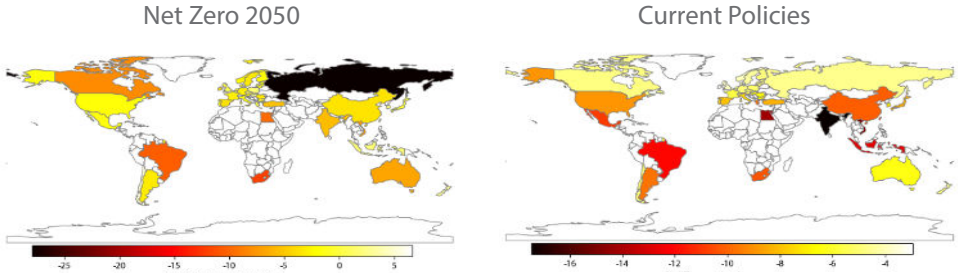
- **Focusing on transition and chronic physical risk only,** in the *Net Zero 2050* scenario, developing Europe* and United States face the highest combined GDP damages in the short-term, while Latin America faces the largest GDP deviations after 2040. By 2050, the *Current Policies* would result in a much more severe GDP impact everywhere, suggesting a further and broad deterioration of the macroeconomic environment afterwards.

- **Focusing on acute physical risk,** droughts and heatwaves are estimated to represent the largest source of risk across regions, with Europe and Asia mostly exposed to heatwaves, while Africa and North America primarily exposed to drought*.

Regional Combined GDP Impact (NiGEM based on REMIND input)



Combined GDP Impact by Country in 2050 (NiGEM based on REMIND input)



% difference, local currency.

% difference, local currency.

* In the NiGEM model, Developing Europe is composed of Albania, Belarus, Bosnia and Herzegovina, Cyprus, Kosovo, Luxembourg, Malta, Montenegro, Serbia, Moldova, Macedonia, and Ukraine.

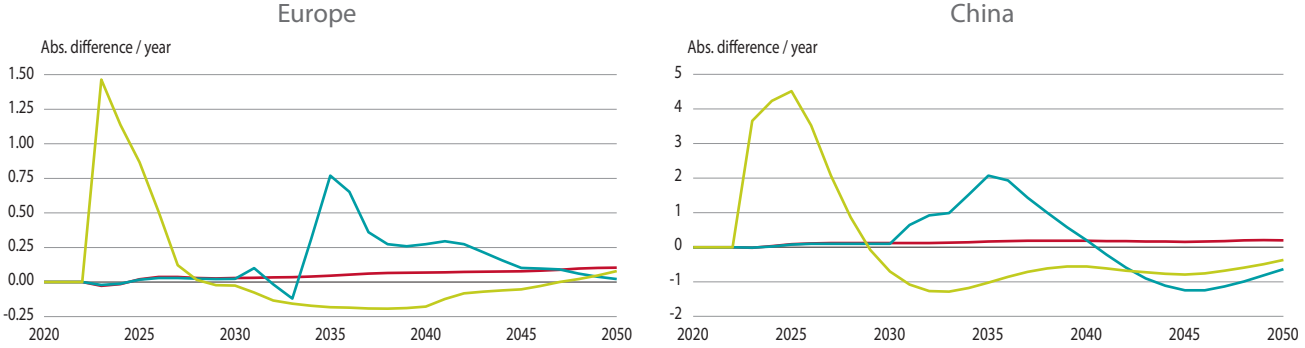
Notes: Charts are based on transition and chronic physical risk only; white means 'data not available'.

Inflation and unemployment

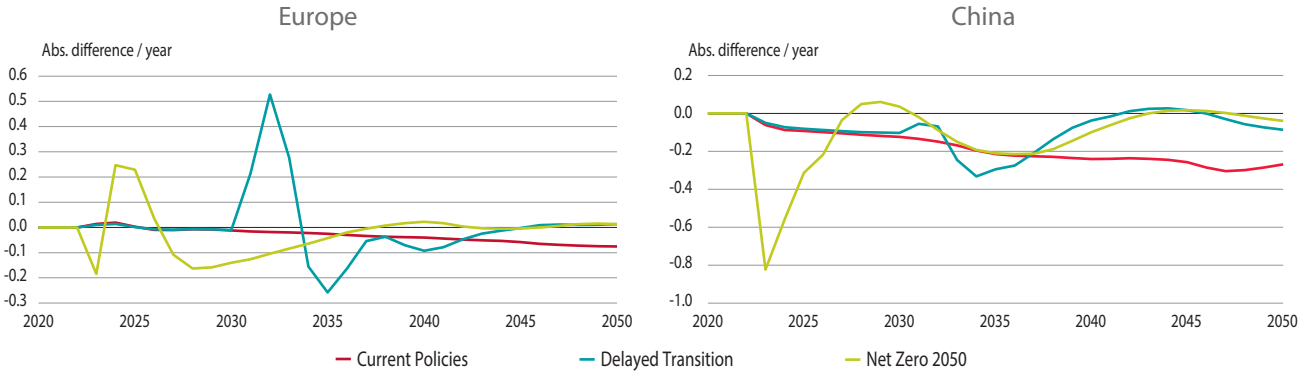
The NGFS scenarios include a wide range of macroeconomic variables, capturing structural relationships between key aggregates such as unemployment and inflation that differ across regions.

- In many countries, the implementation of (shadow) **carbon pricing** in transition scenarios tends to raise energy costs in the short term, which initially weighs on prices (as lower demand and financial market losses affect output). Subsequently, higher (shadow) carbon prices result in modest increases in inflation and unemployment before returning to previous trends. In some countries and time periods, the offsetting growth effects from carbon revenue recycling lead to a reduction in unemployment.
- In some scenarios this leads to a potential **monetary policy trade-off**. The NGFS modelling framework assumes a "two-pillar" strategy, targeting a combination of inflation and nominal GDP as a default.
- **Inflation.** The *Net Zero 2050* scenario illustrates an initial steep rise in inflation, capturing price spikes due to immediate transition policy action. The *Delayed Transition* scenario sees inflation deviate sharply from the baseline around 2030, when the deferred transition begins.
- **Unemployment.** The initial increase in unemployment in the *Net Zero 2050* scenario reverts quickly in Europe, slightly later in China. Furthermore, Europe sees highly volatile deviations from baseline unemployment at the onset of the *Delayed Transition* scenario in the 2030s.

Inflation Rate Deviations (Combined Risk, NiGEM based on REMIND input)



Unemployment Rate Deviations (Combined Risk, NiGEM based on REMIND input)



Interest rates

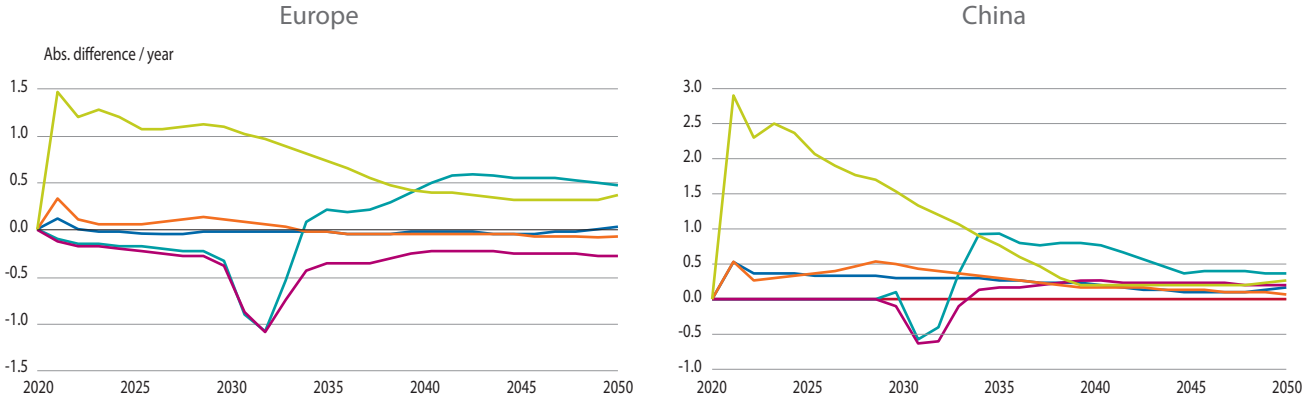
Climate change and transition policies create significant financial fluctuations, producing changes to interest rates that differ across scenarios and over time.

- **Policy interest rates** spike initially in the Net Zero 2050 scenario. They decrease slightly after 2030 in the Fragmented World and Delayed Transition scenario. By 2050, policy rates stabilize at slightly different levels across scenarios, a phenomenon which can also be observed for long-term interest rates.

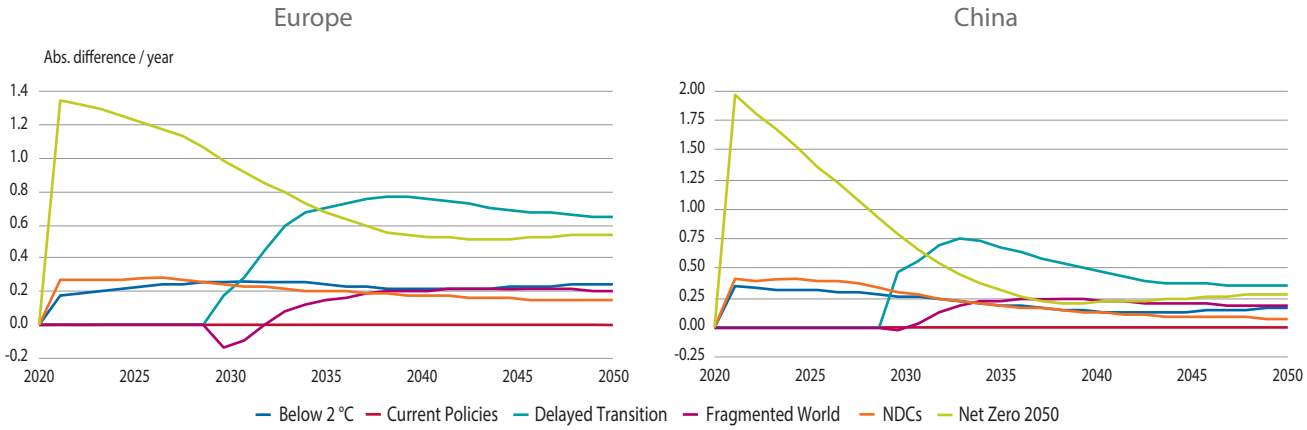
- **Long-term interest rates** tend to increase in the short-term transition scenarios, reflecting the inflationary pressure created by shadow carbon prices, as well as the increased investment demand that the transition spurs on.

- Disorderly transitions can affect **real financial asset valuations** significantly, with considerable regional differences. Although the NiGEM results cannot be disaggregated into individual sectors, it is likely that sectors that can decarbonize less easily will be affected more than other sectors. The NGFS will work to further develop sectoral impacts going forward.

Central Bank Intervention (Policy Interest Rate) (Combined Risk, NiGEM based on REMIND input)



Long-term Interest Rate (Combined Risk, NiGEM based on REMIND input)



Main results of the NGFS Scenarios

Transition risk

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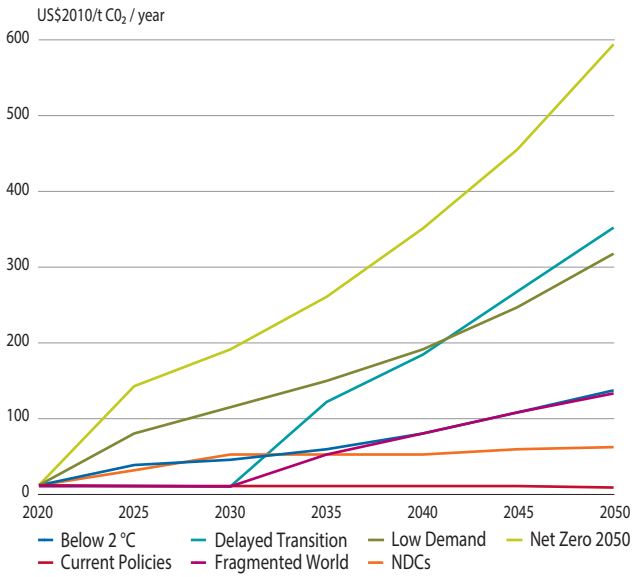
Shadow carbon prices and emission volumes

Reducing carbon emissions will affect all sectors and poses transition risks for the economy and financial system if not anticipated. A key indicator of the level of transition risk is the (shadow) carbon price, a proxy for government policy intensity and changes in technology and consumer preferences.

- **Transitioning away from fossil fuels and carbon-intensive production and consumption requires a significant shift towards emissions-neutral alternatives in all sectors.** Policymakers can induce this transition by increasing the implicit cost of emissions. As it takes time to develop and deploy alternative technologies, climate policies may lead to higher costs in the interim.
- **In the IAMs used to produce the NGFS scenarios, a higher (shadow) carbon price(*) is a proxy for more stringent policy.** Models suggest that a shadow carbon price of around \$200/tCO_2 would be needed in the next decade to incentivize a transition towards net zero by 2050. Except for Current Policies, shadow carbon prices rise in all scenarios and models.
- **The increase in shadow carbon price translates into more ambitious emissions reductions, with heterogeneous sectoral behaviors.** In the *Net Zero 2050* scenario, the Energy Supply sector is responsible for the sharpest drop in emissions. By 2050, the largest emitter is the Transportation sector, where moving away from fossil fuels presents several challenges, while the Industry sector is expected to almost eliminate its net GHG emissions.

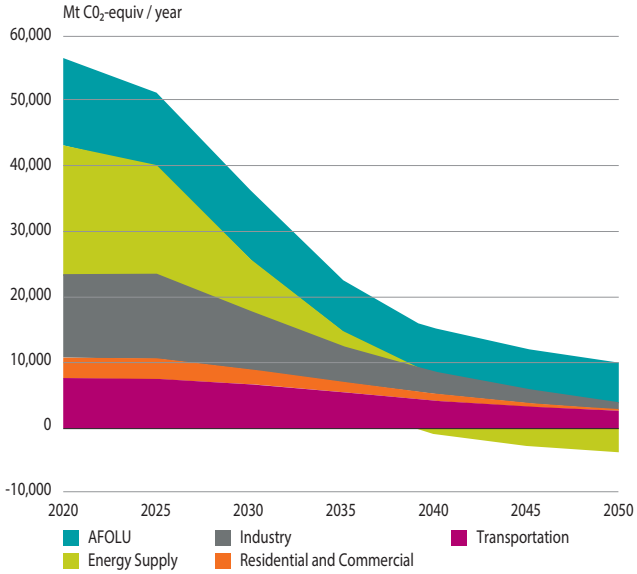
Shadow Carbon Price

REMIND



Global Sectoral Kyoto Gases Emissions

Net Zero 2050, REMIND



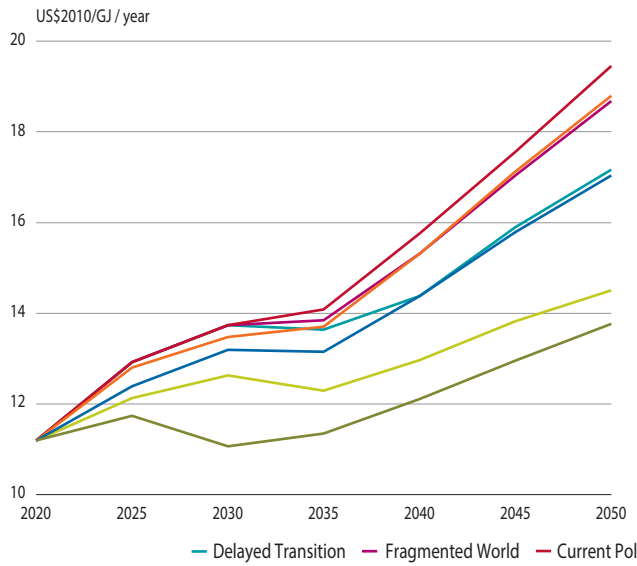
Notes: (*) Prices tend to be lower in emerging economies as policy stringency is lower and there tends to be a greater number of low-cost abatement options still available.

Energy prices

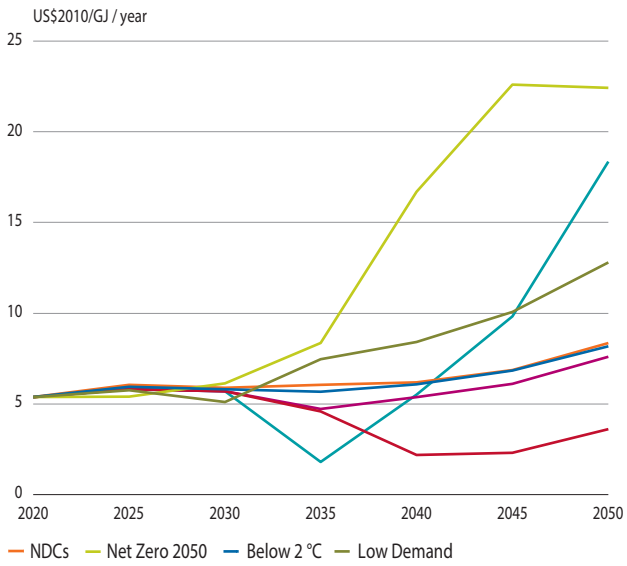
Oil prices rise gradually in all scenarios, but most intensively in Current Policies, whereas biomass experiences highest price increases in the Net Zero 2050 scenario.

- **Oil prices are expected to increase in all scenarios by 2050,** only in the Low Demand scenario a temporary dip in prices can be observed.
- **In the Hot House World (Current policies and NDCs) and Fragmented World scenarios, oil price inflation will be exceptionally high.** Although price increases are also expected in the Orderly scenarios, they will remain relatively limited for Low Demand and Net Zero 2050.
- **Biomass prices diverge more across scenarios.** In the Net Zero 2050 scenario, biomass prices will increase significantly and even exceed oil prices. In NDCs, Fragmented World and Below 2 °C scenarios, prices are expected to stay relatively stable.

Oil Price
REMIND



Biomass Price
REMIND





Energy investments

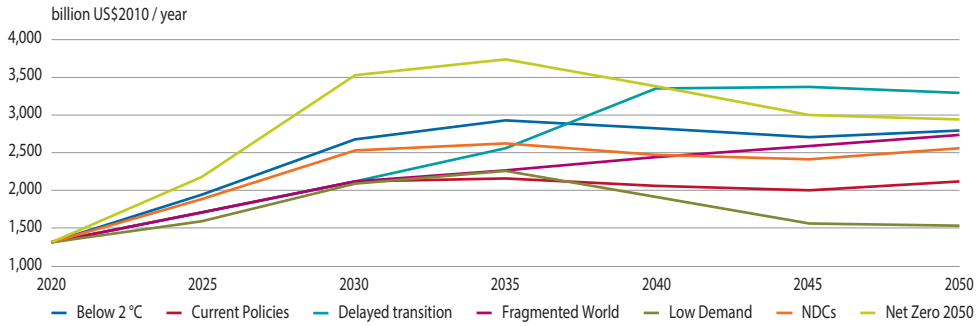
Significant investment flows would need to be directed towards green energy in the coming decades to achieve net zero.

- **Transitioning to a net zero economy would require significant investment flows for an extended period.** All scenarios see a rise in energy supply investments, with increasing levels at least until 2030-2035 (upper chart). Most of the investment efforts are spent in the generation and storage of renewable electricity. In the Net Zero 2050 scenario, the energy investments rise up to more than 2% of global GDP in 2030, doubling from 2020 levels.

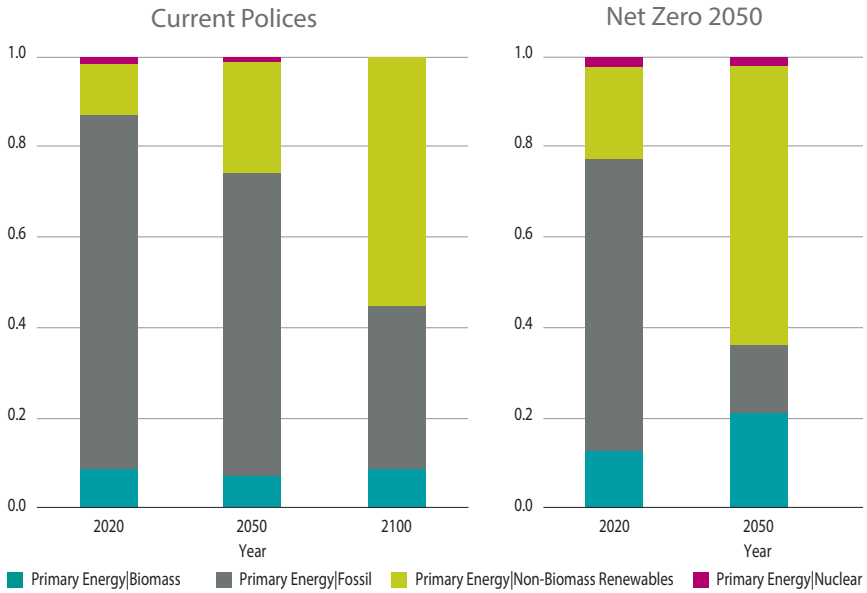
- **By 2050, renewables and biomass would deliver above 80% of global primary energy needs in the Net Zero 2050 scenario** (lower chart). This is a marked contrast to the *Current Policies* scenario where fossil fuels continue to be the dominant source of primary energy, even after accounting for current technology trends.

Global Investments in Energy Supply

REMIND



Global Primary Energy Mix (Calculations based on REMIND outputs)



Main results of the NGFS Scenarios

Physical risk

Modelling of Chronic physical risks

Estimates of GDP losses from chronic risks follow the same modelling approach of phase III, based on a damage function driven by temperature changes.

- Similarly to phase III, GDP losses arising from an increase in global mean temperature are based on the damage function methodology set out in Kalkuhl & Wenz (2020), which can be used to extrapolate observed damages from year-to-year variations in chronic climate hazards due to climate change in the future. The results have been updated with the phase IV GMTs and GDP growth rates.

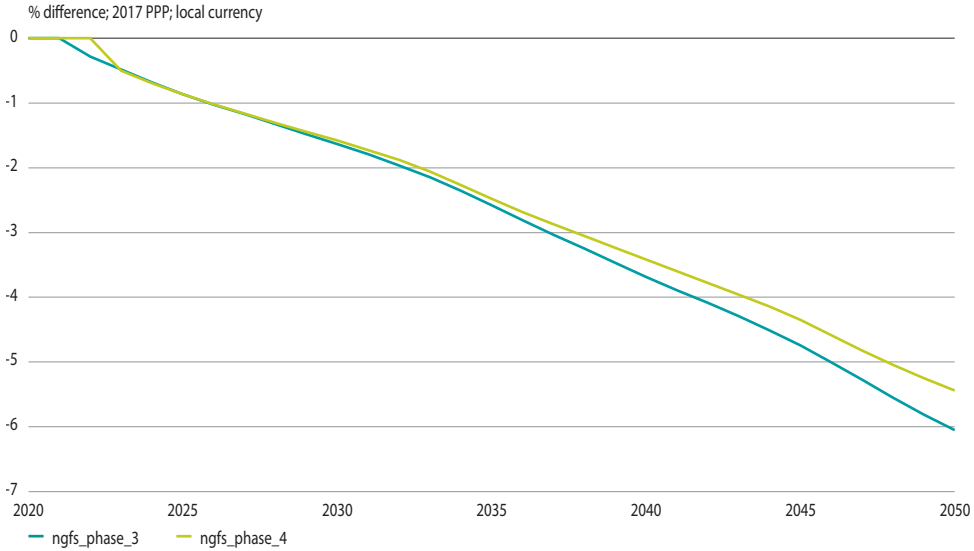
- The 95th percentile of the temperature distribution continues to be used to compute the damages, to reflect the uncertainty inherent in the modelling of the macroeconomic effects of chronic physical risks.

- The GDP losses from chronic physical risks reaches more than 5% in 2050.

- While not included in this vintage, future improvements of the damage function might capture more comprehensively physical chronic risk by to including additional climate drivers (e.g. precipitations) and better capturing long term climate effects (additional to short term GDP losses). This is expected to result in higher damage estimates and the use is conditional on completion of peer review processes.

Chronic Global GDP Impact Phase IV vs Phase III

NiGEM based on REMIND input, Current Policies



Note: In phase IV, the Current Policies scenario was updated to account for the latest climate policies (Fit for 55, IRA…). Therefore, impact from chronic physical risk slightly decreases compared to phase III.

Acute risk modelling: Aggregate global GDP impact results

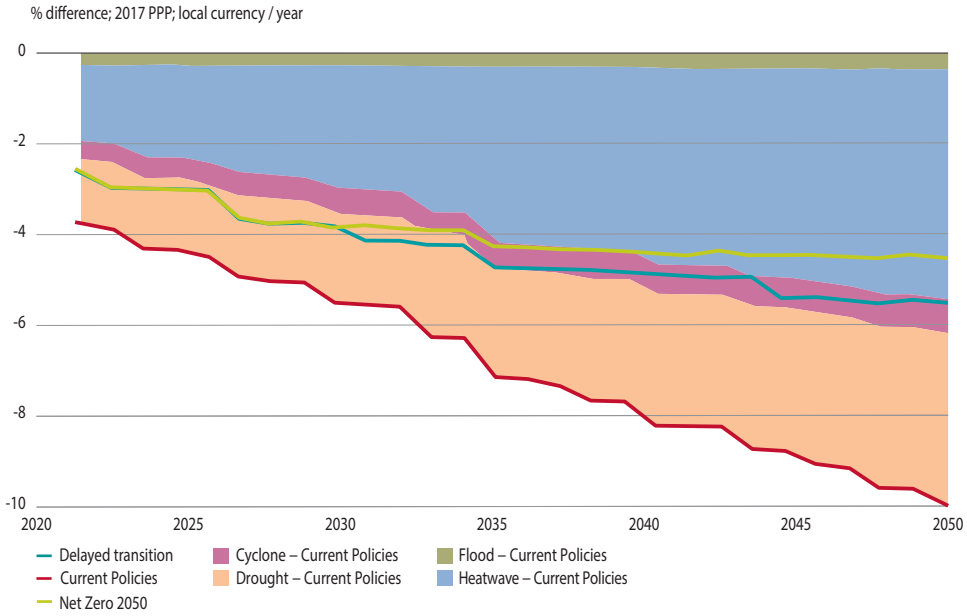
In Phase IV, the NGFS scenarios provide estimates of the macroeconomic impact of acute physical risks based on more advanced physical risk modelling covering four hazards and better capturing their macroeconomic impacts.

- **The model enhancements better capture acute physical risk through:** use of more granular hazard indicators, e.g. standardized precipitation evapotranspiration index (SPEI) for drought, the use of global climate models for projections (e.g. CMIP) and impacts at of aggregated grid point level data for impacts (inputs to NiGEM). NiGEM GDP impacts are estimated using specific transmission channels (e.g. labour productivity for heatwaves)

- Acute physical risk associated with the four modelled hazards is estimated to result in **GDP losses of 8% by 2050 in the *Current Policies* scenario** (deviation from baseline). For comparison, in Phase III the overall acute risk GDP losses were estimated to be about 1.4% relative to the baseline for the Current Policies scenario.

- **In an orderly or delayed transition scenario, GDP deviations from the baseline are estimated to be up** to 3.7% and 4.6% respectively.

Global Acute GDP Impact by Hazard and Scenario



All values are differences from baseline (a hypothetical scenario with no transition nor physical risk); Areas: GDP impact by hazard in a current policies scenario; Lines: GDP impact, all hazards, in the other scenarios.
NiGEM simulations start as of Q1-2023.
Current policies scenario uses damages corresponding to the 95th percentile of the temperature profile to account for tail physical risks, while other scenarios use the 50th percentile.

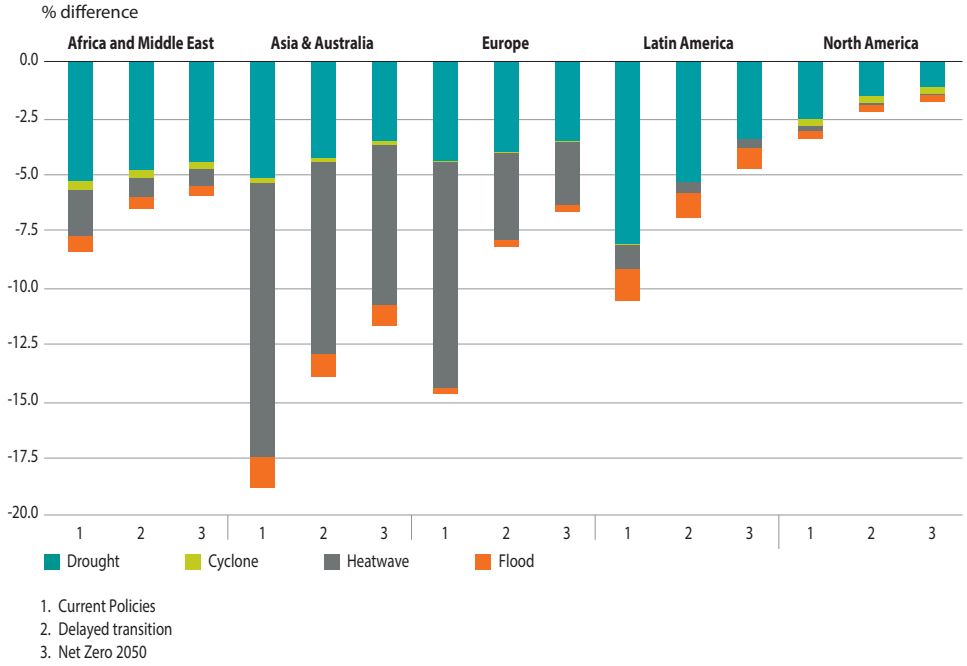
Acute risk modelling: regional GDP impact results

The geographical granularity of the estimates is increased to country-level, which indicate that droughts and heatwaves pose the largest overall risk to GDP, with impacts varying considerably across different regions.

- **Droughts and heatwaves are estimated to represent the largest source of risk across regions,** highlighting the importance of the inclusion of these hazards and associated macroeconomic transmission channels in Phase IV.
- **Countries in Europe and Asia are assessed to be most exposed to heatwaves. Countries in Africa, and North America are primarily exposed to drought.** The lesser impact of floods and cyclones might be driven by the more localised nature of these phenomena and by the different modelling approach.

Regional Acute GDP Impact by Hazard and Scenario

Region Averages



1. Current Policies
2. Delayed transition
3. Net Zero 2050

Notes: additional details and granular information in Annex (slide 54-57).

All values are differences from baseline (a hypothetical scenario with no transition nor physical risk);
Simple averages across countries available for that region.
Latin America is composed by Chile, Mexico and Argentina, with except for Floods, only available for Mexico.
North America includes US and Canada, but only US for floods.
Africa includes Egypt and South Africa (only South Africa for floods).

Challenges to acute physical risk modelling

Despite the substantial progress in the modelling and estimates of acute physical risk in the Phase IV NGFS Scenarios, challenges still exist, and further developments are needed.

The main challenges faced by the current physical risk modelling in the categories of data & validation, models, and usability & coverage are:

Data and validation

- The set of climate indicators utilized could be expanded and improved to provide a better and more complete picture of acute hazards and their transmission to the economy
- Accurate estimation of exposure and vulnerabilities remains a challenge and would benefit from additional reporting and granular datasets
- There is a strong need for validation of the overall model results, as well as the data used in each of the model components

Modelling approaches

- Increase granularity of physical risk estimates, e.g. impact of drought on yields based on type of crops and seasonality, or considering other types of flood (coastal and pluvial) alongside riverine floods
- Improve integration between physical risk models and macroeconomic modelling, e.g. by capturing additional channels of transmission

Usability in the context of climate risk analysis (and coverage)

- Usability by the financial industry might still be hindered by the lack of sectoral breakdowns and of more granular geographical estimates
- Additionally, the inclusion of new channels of transmission could be matched by focusing on additional key variables, as for example impact of drought on food prices, which is an important component of consumer price indices
- The modelling of compound risks could also be considered in future developments

Main results of the NGFS Scenarios

New scenarios in focus

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Low Demand: a new *orderly* scenario

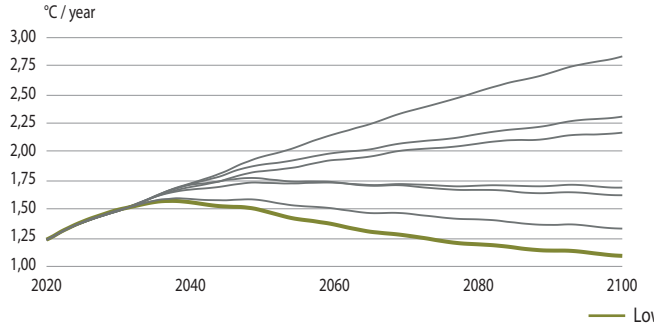
Low Demand **explores the global efforts needed to be able to limit global warming to below 1.5 °C by 2050 in an orderly fashion, aligned with the Paris Agreement, driven by lower energy demands. It shows that reaching the Paris target will require even greater ambition in the future, accompanied by behavioral changes.**

- This new ***Low Demand*** scenario differs from the other orderly scenarios in the following:
- It incorporates the **lower temperature pathway**, while introducing **less progressive (shadow) carbon prices**.
- Global CO_2 emissions reach or approach **net zero in 2050**. Countries with a political commitment to a net zero target defined before the end of 2021 meet this target before or after 2050.
- **Significant behavioral changes** in our energy generation and consumption activities are implemented as scenario assumptions to ensure an orderly, Paris-aligned transition. This is the key distinguishing feature of the *Low Demand scenario* compared to the *Net Zero 2050* scenario. Additional levers in end-use sectors to mitigate the pressure on carbon taxes and induce the transition include reducing **energy demand**, inducing faster **electrification**, and substitution through **renewables**.

Note: Macrofinancial variables are not yet available for the new Low Demand scenario.

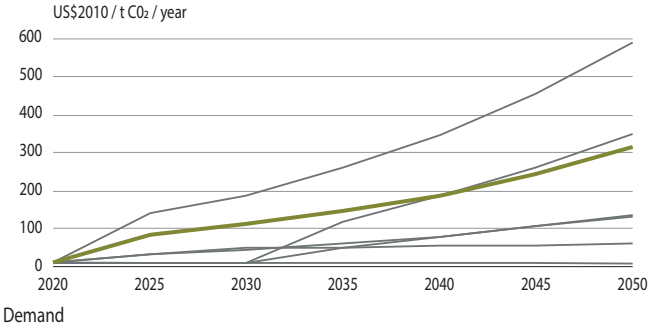
Temperature Pathways

AR6 Surface Temperature (GSAT) increase (50th), MAGICC with REMIND emission inputs



Shadow Carbon Price

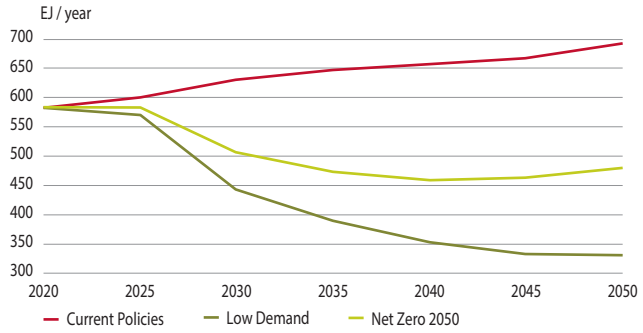
REMIND



Low Demand

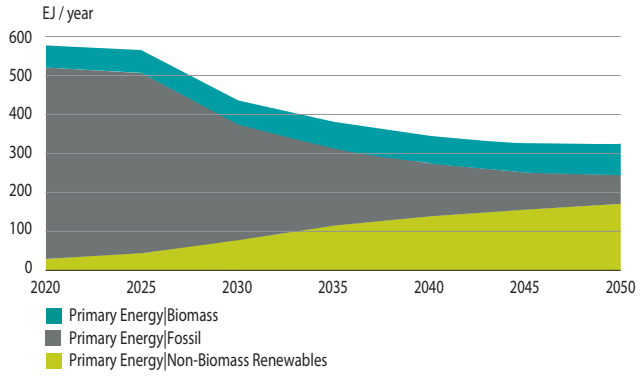
Global Primary Energy Demand across scenarios

REMIND



Global Sectoral Primary Energy Demand - Low Demand

REMIND



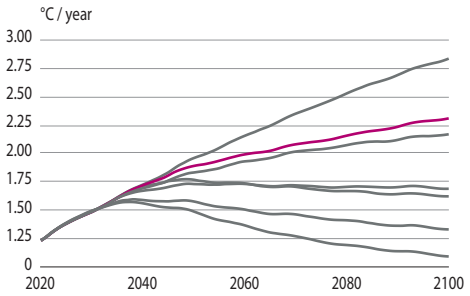
Fragmented World: a new *too little, too late* scenario

Fragmented World assumes a delayed and divergent climate policy response among countries globally, leading to high physical and transition risks at the same time.

- The new ***Fragmented World*** scenario helps to:
  - Emphasize the critical role played by **international policy coordination** (or the lack thereof)
  - Explore **more adverse impacts** if we fail to implement climate mitigation policies in a timely and globally coordinated manner, which can be used as a baseline for climate stress tests.
- Only currently implemented policies are maintained until 2030 (**delayed transition**); thereafter, countries that have set themselves a net zero target only reach an 80% reduction by 2050, while others continue with current policies (**divergent transition**).
- This delayed and divergent transition leads to a temperature rise of an across model average of 2.3 °C at the end of the century, corresponding to a physical risk level not far from the one of Current Policies.
- In line with this new narrative, (shadow) carbon prices and amounts of investment are very different across geographies, with some countries' ambitious efforts being undermined by limited action in some others. At the same time, climate policies differ significantly across sectors: the transport and buildings sectors experience (shadow) carbon prices three times as high as the rest of the economy.
- The combination of these misaligned efforts across countries and sectors leads to even higher transition risks than in the Delayed Transition scenario, in which transition risks are subdued by efficient inter-regional and inter-sectoral distribution of transition efforts.

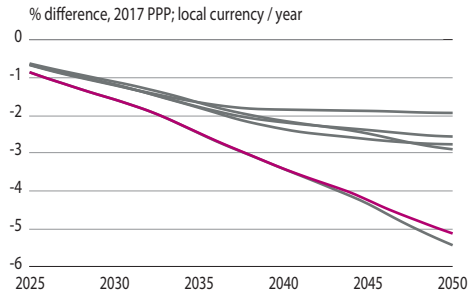
Temperature Pathways

AR6 Surface Temperature (GSAT) increase (50th), MAGICC with REMIND emission inputs



Chronic Global GDP Impact

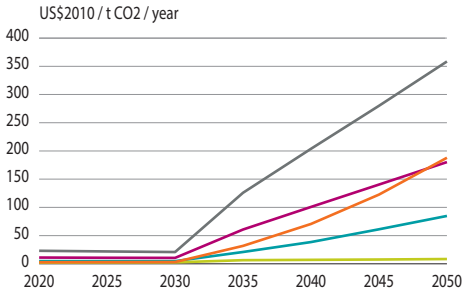
NiGEM based on REMIND input



Fragmented World

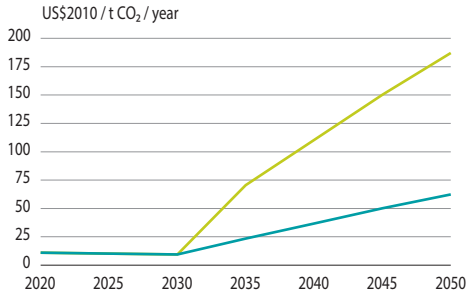
Regional Shadow Carbon Price

Fragmented World, REMIND



Sectoral Shadow Carbon Price

Fragmented World, REMIND



Data access, tools and resources

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Accessing NGFS scenario data

NGFS climate scenario data are available in two platforms. There are several ways to access the data, which serve different users' data needs and analytical requirements.

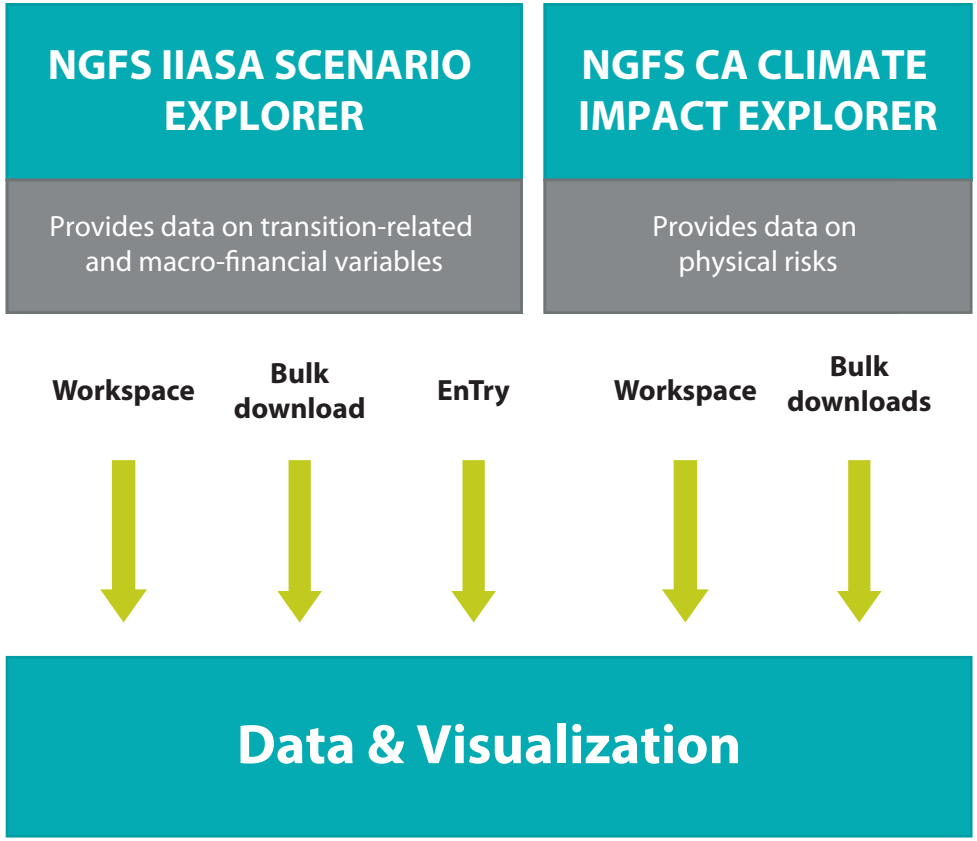
The NGFS scenarios provide a range of data on transition, physical and economic impacts produced by a suite of models aligned in a coherent way.

Data from the IAMs and NiGEM, covering **transition and macro-financial pathways**, can be found in the **NGFS IIASA Scenario Explorer**. Data on acute and chronic **physical risk impact** is stored on the **NGFS CA Climate Impact Explorer**.

There are three main ways to access NGFS climate scenario data:

- **Workspaces:** Both data explorers provide online interfaces to visualize and explore the data. Here users can explore and compare scenarios, regions, variables, and models.
- **Downloads:** Data can be downloaded in bulk as .csv or .xlsx data frames from the NGFS IIASA Scenario Explorer.
- **Code-based access:** Both data explorers provide direct APIs to access the data in coding scripts directly. To facilitate users' access to this method, the **NGFS EnTry Tool** is now available.

More details on how to work with the data are available in the **NGFS User Guide**.



NGFS Data Engagement and Transparency Tool

The NGFS Data Engagement and Transparency (EnTry) Tool is a new code-based data handling tool that supports users from data extraction to visualization within one platform.

Key Features

USABILITY
- Open-source
- Full shareability
- User-friendly interface
- Single-platform solution

TRANSPARENCY
- Reports available with source script
- Data handling methods fully visible

FLEXIBILITY
- Online and local usability
- Usable on any device
- Extendable with custom code

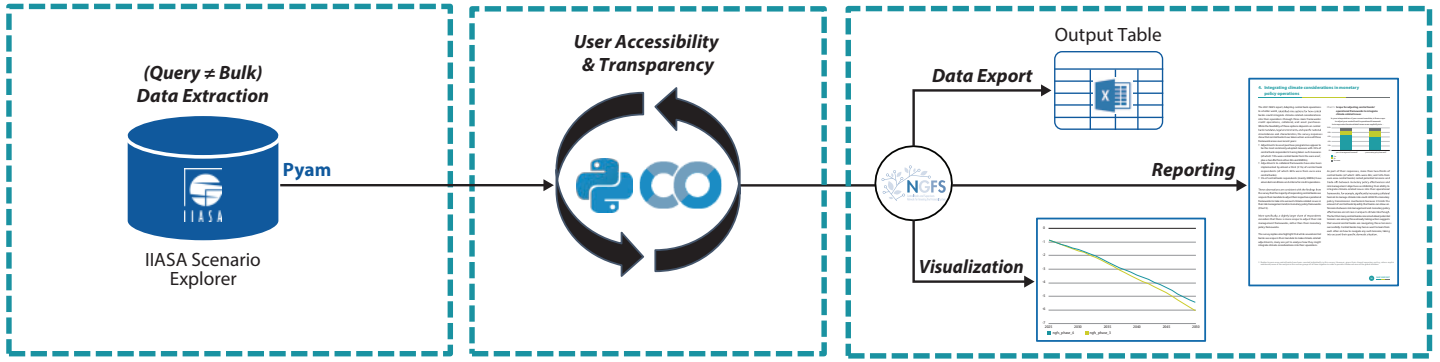
FUNCTIONALITY
- Cross-phase features
- Data querying
- Data manipulation
- Data visualization

Components

Pyam-iamc:
- *Allows direct connection to data and functionalities for all users.*
- *Provides user support in form of extensive documentation and user technical support (Github & Slack).*

Google Colab:
- *Makes code, data and visuals shareable.*
- *Avoids local installations, without network and access rights issues.*

NGFS Chair Reporting Layer
- *Offers scripts, data, visualizations and reports.*
- *Allows users to access, reproduce and generate scenario narratives.*
- *Outputs can be in diverse formats and are easily shareable.*



More details on how to work with the data with the EnTry toolkit are available in the NGFS User Guide.

NGFS Data Engagement and Transparency Tool

The NGFS Data EnTry Tool allows users to build their own scripts to analyse the scenario data of interest starting from pre-defined templates. The tool includes several scripts to showcase its features and examples to facilitate its use.

Current Scripts

- **Demo of all basic functionalities**
  - Gives a tour through the functionalities of the tool.
- **Quick Query Tool & Parameter Guide**
  - Provides an easy ad hoc way to query and download data across models, scenarios and phases, as well as plot in NGFS style.
- **Quick Map Tool**
  - Provides an easy ad hoc way to produce maps based on available country-level data across models, scenarios and phases.
- **Report Template**
  - Template to create NGFS-themed reports with plots and descriptions.

The NGFS Data EnTry Tool is available on the NGFS scenario portal under Data & Resources, together with the NGFS User Guide.

Revamped technical documentation

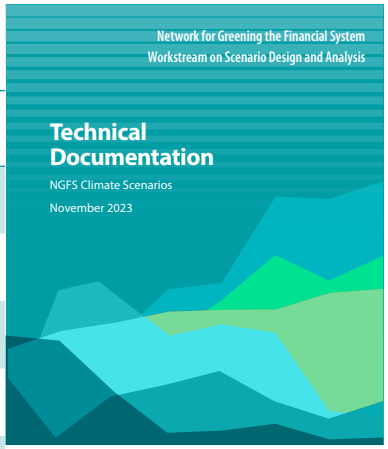
The technical documentation accompanying the NGFS scenarios has been completely redrafted following a modular approach. The new format allows readers with different levels of expertise and interest to better focus on the information relevant to them.

The revamped technical documentation includes:

- **High-level overview** for non-expert users
- **Technical modules** for each modelling component
- **Non-technical summaries** for each modelling component
- **Boxes** with explainers and deep-dives

The NGFS technical documentation can be downloaded directly at this link.

	Modules
1	High-level overview
2	REMIND-MAgPIE
3	Message
4	GCAM
5	NiGEM
6	Chronic physical risk
7	Acute physical risk
8	Country downscaling
	Technical Appendix



Overview of resources on NGFS scenarios



Data

- IIASA portal
- Climate Impact Explorer
- NGFS EnTry Toolkit



Web resources

- NGFS scenarios portal



Explanatory material

- Presentation on Phase IV scenarios
- Technical documentation
- Q&A and/or FAQ
- NGFS dashboard on IMF website

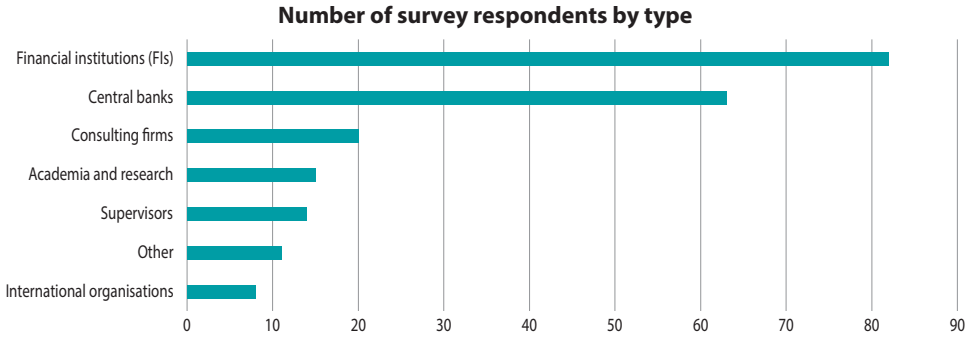
Outcome of the first NGFS user feedback survey

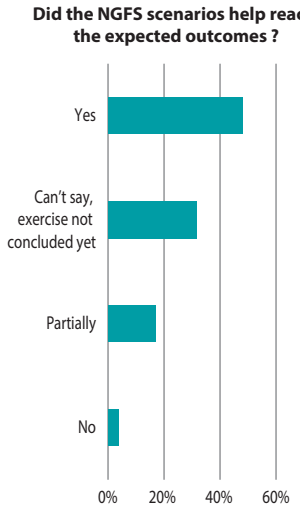
The NGFS conducted a survey among climate scenario users to better understand how the scenarios are used and what can be improved.

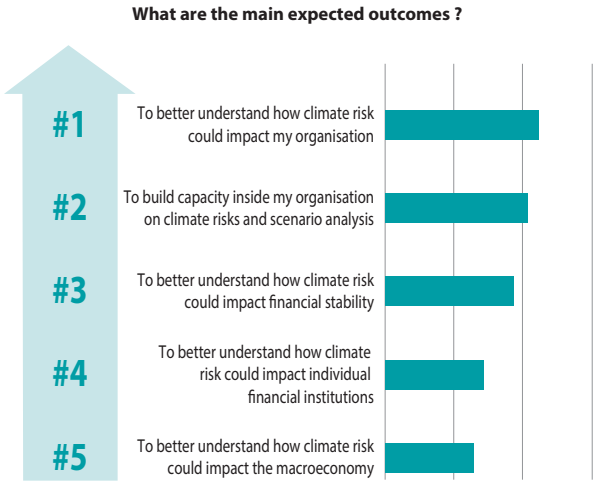
- **The survey reached both the public and private sector, with most responses coming from financial institutions, central banks and consulting firms.** In total, 213 responses from 57 countries were collected. Respondents self-assessed themselves as more experienced with NGFS scenarios compared to alternative scenarios (e.g., IEA and IPCC).

- **NGFS scenarios have become a key ingredient to identify climate risks globally:** over 70% of respondents from both the private and public sector use them, mostly to better understand the impacts of climate risks and to build internal capacity. Almost all respondents consider the NGFS scenarios as a true public good. The NGFS framework is also positively evaluated compared to other climate scenarios.

- **Key areas for technical improvement are the magnitude of transition risk and sectoral granularity.** Users would also benefit from better understanding the modelling framework and output and more guidance on how to use the scenarios for concrete applications and how to access and identify key output variables.



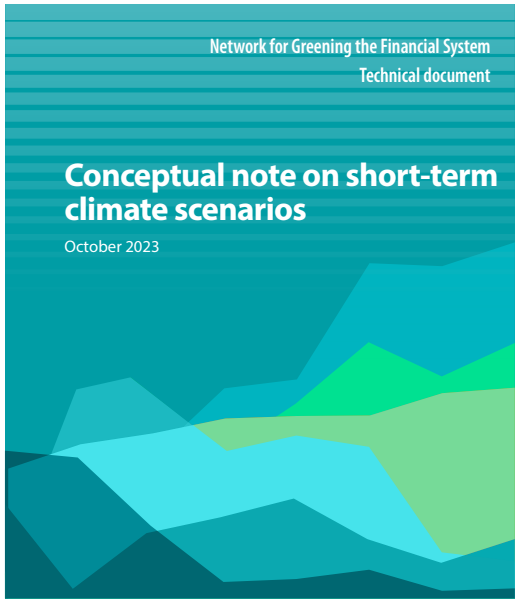




What's coming next

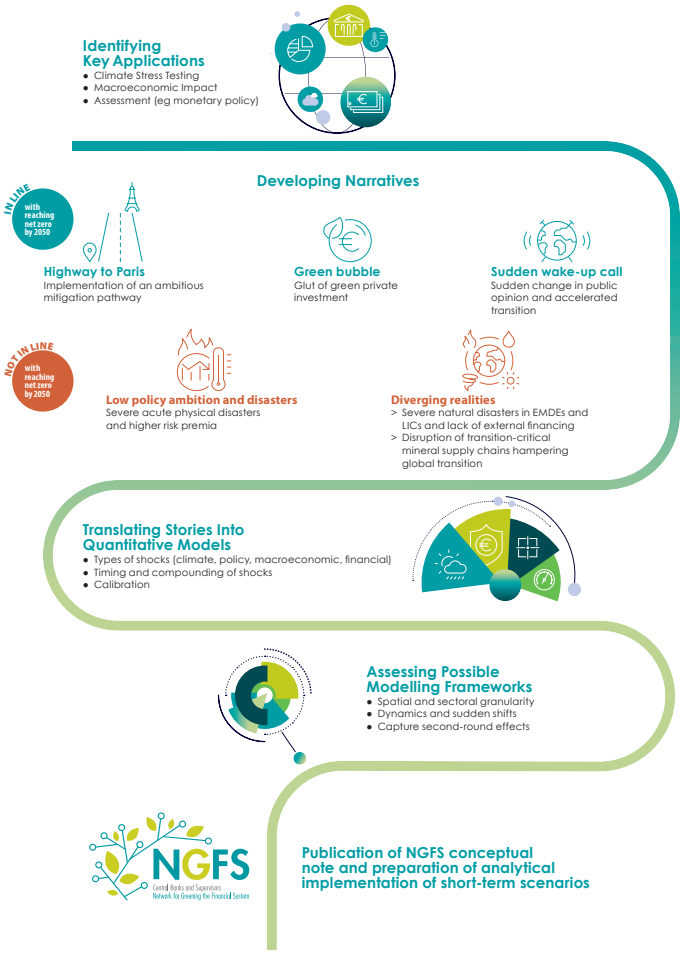
NGFS short-term scenarios: conceptual note

A conceptual note on short-term climate scenarios to document the NGFS *thinking process* and give a roadmap of the work ahead has been published in **October 2023.**



Accessible via NGFS Portal

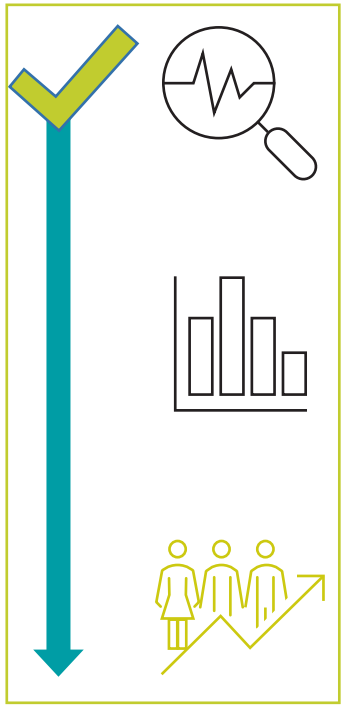
Exploring upcoming climate risks: the NGFS's journey towards short-term climate scenarios



NGFS short-term scenarios: first vintage

A modelling team to *calibrate the NGFS short-term scenarios* has been *selected* following a Call for Expression of Interest and is envisaged to start working on *the scenarios* by the *end of 2023*.

Roadmap



- Selection of an external team of modelers to calibrate the scenarios.
- Close synergies across the different working groups of the NGFS on macroeconomic modelling.

Scenario narratives selected from…

IN LINE with reaching net zero by 2050



HIGHWAY TO PARIS
> Implementation of an ambitious mitigation pathway
> Boom in green public investment
> Fast transition supported by green technology



GREEN BUBBLE
> Glut of green private investment
> Build-up of a green credit bubble
> Burst of the bubble, sharp rise in risk premia and confidence crisis



SUDDEN WAKE-UP CALL
> Sudden change in public opinion and accelerated transition
> Stranded assets in polluting sectors
> Financial stress that propagates internationally

NOT IN LINE with reaching net zero by 2050



LOW POLICY AMBITION AND DISASTERS
> Severe acute physical disasters and higher risk premia
> Freeze of private investment in exposed areas
> Lower households consumption due to uncertainty and higher insurance costs



DIVERGING REALITIES
> Severe natural disasters in EMDEs and LICs and lack of external financing
> Disruption of transition-critical mineral supply chains hampering global transition
> Sudden re-assessement of future physical impacts leading to higher risk premia globally

Phase IV scenarios: planned updates

An update of the NGFS (Phase IV) scenarios will be published in the course of 2024*, including further sectoral disaggregation and possibly a new chronic physical risk damage function.

Phase IV scenarios will receive two further updates after initial release:

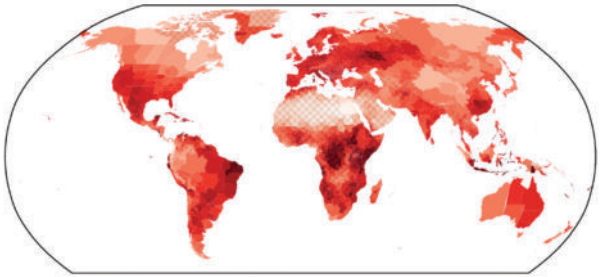
1. Improving sectoral disaggregation

- Transition risks have already been represented with increased granularity in the transport and industry sector in Phase III,
- The new work-in-progress downscaling methodology would cover more economic sectors and a much more granular breakdown of activities.

2. Enhancing chronic physical risk damage function

- The current damage function by Kalkuhl and Wenz (2020), which only accounts for increases in global mean temperature, will be updated to its latest version, which also incorporates other climate variables, such as precipitation and temperature variability *(see charts on the right)*, as well as the persistence of climate impacts.

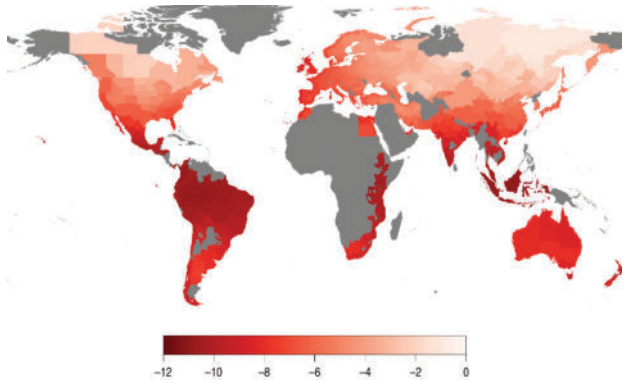
Number of wet days



Global/sample mean: –1.35/–1.34

Effect on economic growth rates of a 1-s.d. shock

(% points)



Change in growth rates per extra degree of day-to-day temperature variability

* Expected release date depends on the publishing of Kotz et al.'s most recent article on this damage function, which is currently being peer-reviewed.

The graphics are from Kotz et al. (2021) and Kotz et al. (2022).

Towards Phase V scenarios

The NGFS has decided to switch to 2-year development cycles starting from Phase V, to be complemented with annual (mechanical) updates of the scenarios.

At the end of 2022, the NGFS has developed a **multi-year work program** centred around five strategic priorities, and **five different substreams** have been created to ensure the objectives will be reached. The work program and the workstream structure will be reassessed at the onset of Phase V to ensure that they remain fit for purpose.

Sub-stream 1: Scenario narrative and updates

Expand and update scenarios and underlying models, e.g., including recent policy actions, limiting CDR availability and including energy sector ramifications of the Russian war in Ukraine

Sub-stream 2: Short-term scenarios

Develop a conceptual framework for short-term scenarios, including narratives, shocks and modelling frameworks that cater to needs of climate stress tests, followed by its analytical implementation

Sub-stream 3: Physical risk

Expand and refine approach for acute risk impact, refine macroeconomic damage function, potentially close the loop between physical risk and transition scenarios

Sub-stream 4: Sectoral granularity

Provide sector-level macro-financial output

Sub-stream 5: Communication and engagement

Develop communication strategy, collect users' feedbacks, disseminate scenarios and organise outreaches

NGFS scenarios

October 2023

Contacts

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ECB Chair's Team of the NGFS Workstream on Scenario Design and Analysis:

NGFS_climate_team@ecb.europa.eu

All plots and underlying NGFS scenario data used in this presentation can be retrieved in the EnTry script here.

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Annex

Heatwaves

Heatwaves are extended periods of abnormally hot weather. In the NGFS scenarios, their impact is estimated in terms of productivity and demand shocks based on estimates of exposed population.

1. Heatwaves can affect economic activity in several ways ranging from labour productivity impacts, disruption of supply chains due to impacts on infrastructure, and water scarcity impacts.

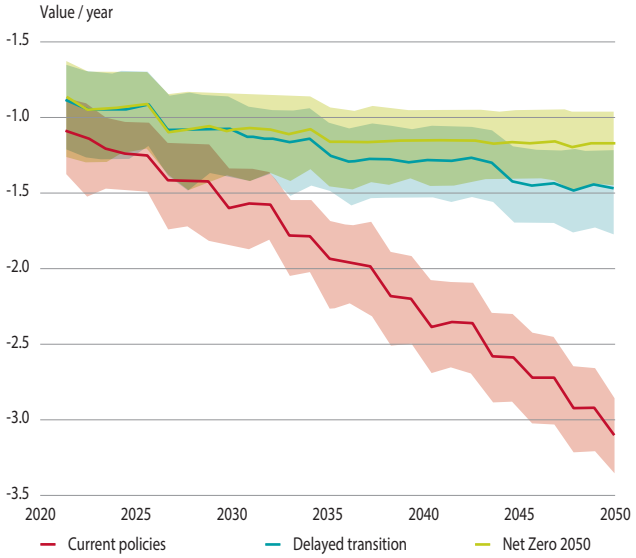
2. In the NGFS Phase IV scenarios, heatwave risk is estimated by estimating the population exposed to dangerous levels of heat stress, then converted into productivity and demand shocks to the economy in NiGEM.

Resulting estimates show that

- **Projected GDP losses due to heatwaves at world level in a Current Policies scenario reach about 3.1% by 2050,** 1.9% above an orderly transition (<1.5 degrees) scenario.
- **The losses estimates vary across countries,** with high impacts in Europe and Asia.

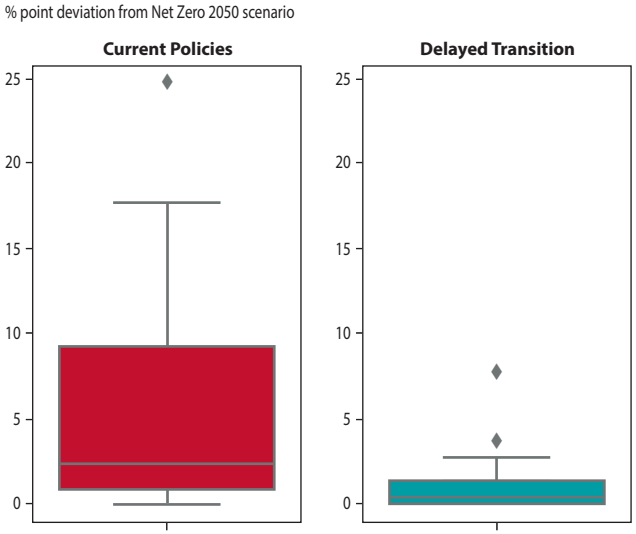
Global Acute GDP Impact from Heatwaves

90pct impacts with 60-99pct bands



Country Deviations in Global Acute GDP Impact from Heatwaves in 2050

Scenario Deviation Compared to Net Zero 2050



All values are cumulative differences in GDP growth (ppt) from baseline (a hypothetical scenario with no transition nor physical risk).

All GDP values used in charts are differences from baseline.

Droughts

A drought is defined as a lack of water, typically due to a lack of precipitation. In the NGFS scenarios, the effect of a drought is estimated via the potential impact on crop yields affecting productivity, exports and prices.

1. Drought conditions are detrimental to ecosystems and a broad range of sectors, including agriculture, energy, and other water-intensive sectors.

2. In the NGFS Phase IV scenarios, drought risk is estimated via national crop yield impacts (estimated based on gridded drought hazard indicators combined with harvested area data) affecting the economy via shocks to productivity, exports and prices in NiGEM.

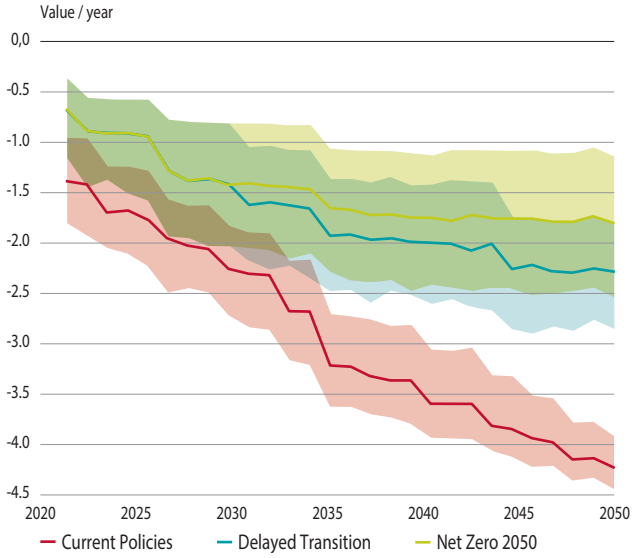
Resulting estimates show that

- **Projected GDP losses due to droughts at world level in a Current Policies scenario exceed 4.2% by 2050,** over 2.4% above an orderly transition (<1.5) scenario.

- **Higher drought risk is shown in countries around tropical and subtropical climate zones,** in particular in South America and Asia.

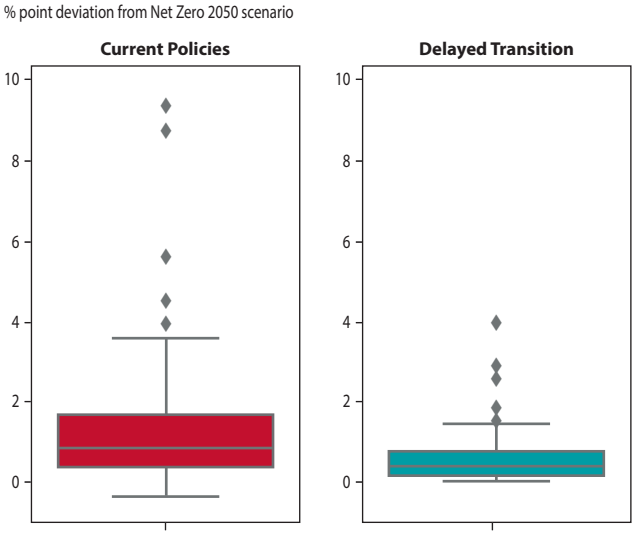
Global Acute GDP Impact from Droughts

90pct impacts with 60-99pct bands



Country Deviations in Global Acute GDP Impact from Droughts in 2050

Scenario Deviation Compared to Net Zero 2050



All GDP values used in charts are differences from baseline.

Floods

Riverine floods are inundation events resulting from rivers overflowing their banks. In the NGFS scenarios, riverine floods have a direct impact on capital due to asset damages.

1. Riverine floods occur when rivers overflow and overcome flood protections, with potential high impacts on residential, commercial, agricultural and industrial assets, as well as on supply chains (e.g., due to business and transport infrastructure disruptions).

2. In the NGFS Phase IV scenarios, flood risk is estimated via capital stock damages affecting the economy via investment premia shocks in NiGEM.(*) Capital stock damages are estimated based on output from global hydrological models, combined with flood protection data, gridded capital stock estimates, and depth-damage functions.

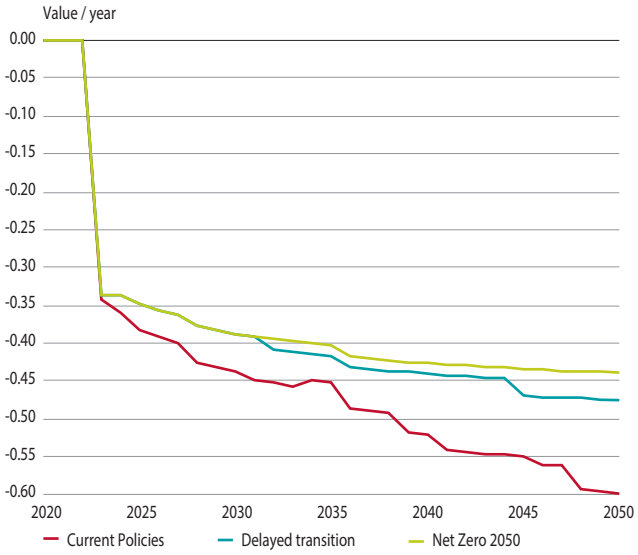
Resulting estimates show that

- **Projected GDP losses from riverine floods at world level in a current policies scenario exceed 0.6% by 2050,** about 0.15% above an orderly transition scenario.

- The losses distribution shows **higher losses in tropical and subtropical areas, in particular in Asian and African regions.**

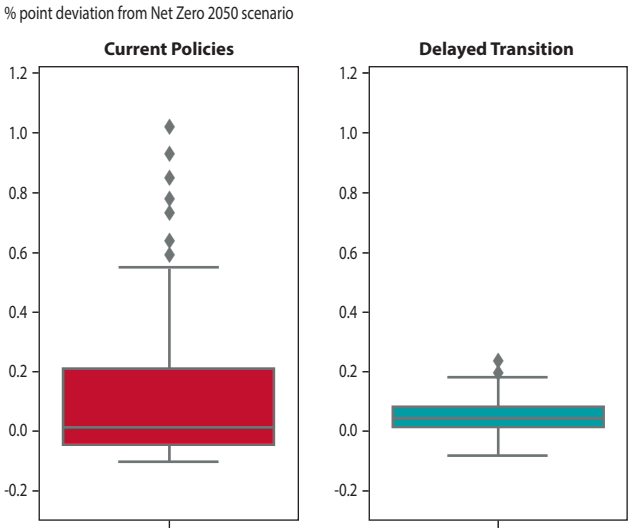
Global Acute GDP Impact from Floods

90pct impacts



Country Deviations in Global Acute GDP Impact from Floods in 2050

Scenario Deviation Compared to Net Zero 2050



Notes: (*) GDP impacts are estimated in NiGEM as a single shock (based on estimated average annual damages) rather than as a stochastic simulation as for the other hazards.

Tropical Cyclones

Tropical cyclones are highly destructive weather phenomena that form over warm tropical oceans. In the NGFS scenarios, they have a direct impact on capital due to asset damages.

1. Tropical cyclones, also known as typhoons or hurricanes, typically occurring between 5° and 30° latitude North and South. Their impact is concentrated on infrastructure but, like floods, can affect the economy via various channels (e.g. supply chains disruptions).

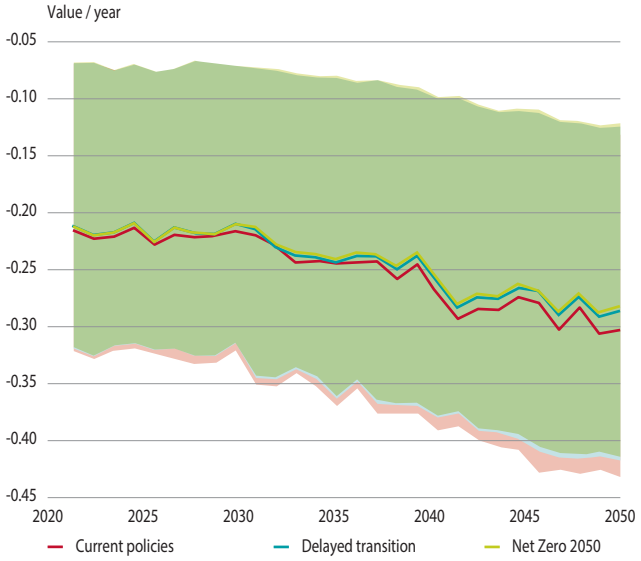
2. In the NGFS Phase IV scenarios, the CLIMADA model is used to simulate a probabilistic set of tropical cyclones under current and potential future climate conditions, combining the hazard data with exposure and vulnerability estimates calibrated with EM-DAT to estimate capital stock damages, affecting the economy via investment premia shocks in NiGEM.

Resulting estimates show that

- **Projected GDP losses from tropical cyclones at world level in a Current Policies scenario amount to about 0.2% GDP loss by 2050.** This probably reflects the fact that tropical cyclones are limited to a latitude band and primarily affect coastal regions.

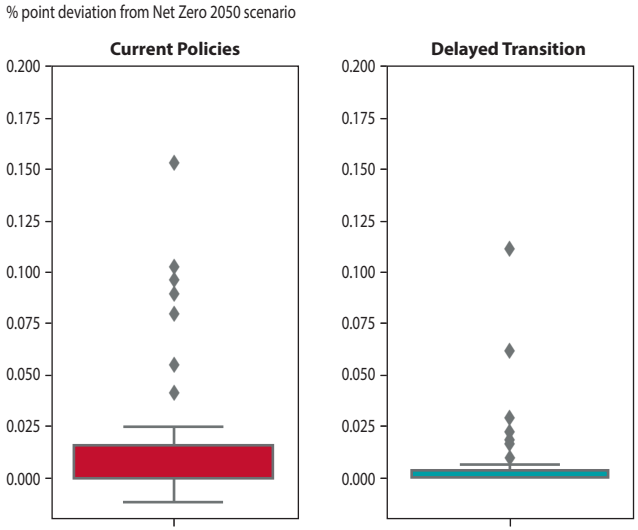
Global Acute GDP Impact from Cyclones

90pct impacts with 60-99pct bands



Country Deviations in Global Acute GDP Impact from Cyclones in 2050

Scenario Deviation Compared to Net Zero 2050



All GDP values used in charts are differences from baseline.

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