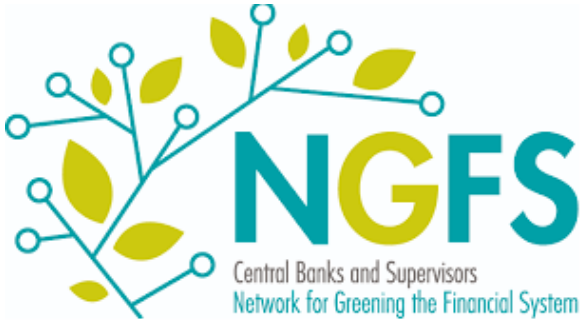


NGFS Scenarios

Phase III

Laura Nowzohour

European Central Bank
Chair's Team of NGFS Workstream 2 on Climate Scenarios

Objectives and framework

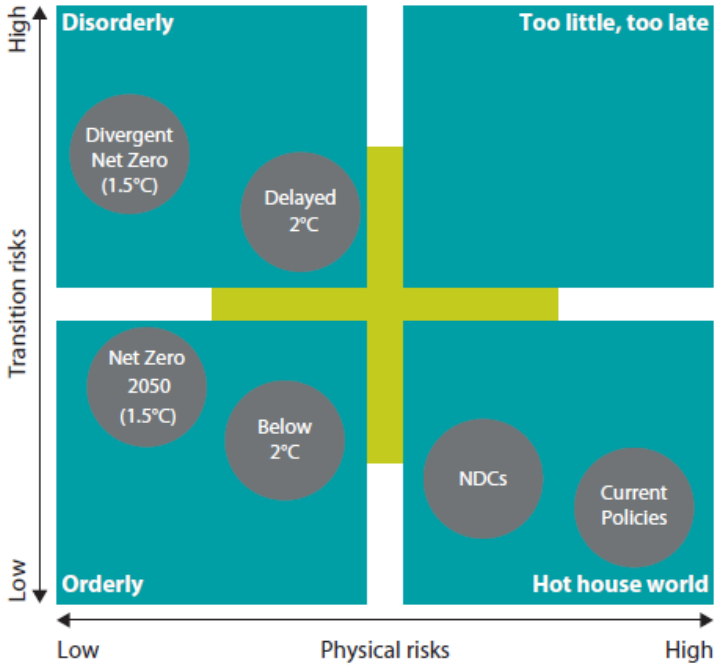
The NGFS scenarios explore the impacts of climate change and climate policy with the aim of providing a common reference framework.

The NGFS scenarios explore a set of **six scenarios** covering three categories:

- **Orderly** scenarios assume climate policies are introduced early and gradually; both physical and transition risks are relatively subdued.
- **Disorderly** scenarios explore higher transition risk due to policies being delayed or divergent across countries/sectors, resulting in higher carbon prices.
- **Hot House World** scenarios assume that some climate policies are implemented in some jurisdiction, but global efforts are insufficient, resulting in severe physical risk with irreversible impacts.

The NGFS scenarios are characterised by their overall **level of physical and transition risk.**

NGFS scenarios framework



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

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Scenarios at a glance

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			
Category	**Scenario**	**Policy ambition**	**Policy reaction**	**Technology change**	**Carbon dioxide removal –**	**Regional policy variation +**
Orderly	Net Zero 2050	1.4°C	Immediate and smooth	Fast change	Medium-high use	Medium variation
	Below 2°C	1.6°C	Immediate and smooth	Moderate change	Medium-high use	Low variation
Disorderly	Divergent Net Zero	1.4°C	Immediate but divergent across sectors	Fast change	Low-medium use	Medium variation
	Delayed Transition	1.6°C	Delayed	Slow/ Fast change	Low-medium use	High variation
Hot house world	Nationally Determined Contributions (NDCs)	2.6°C	NDCs	Slow change	Low-medium use	Medium variation
	Current Policies	3°C+	None - current policies	Slow change	Low use	Low 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 CO2eq .
^ 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 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 particular countries and/or regions.

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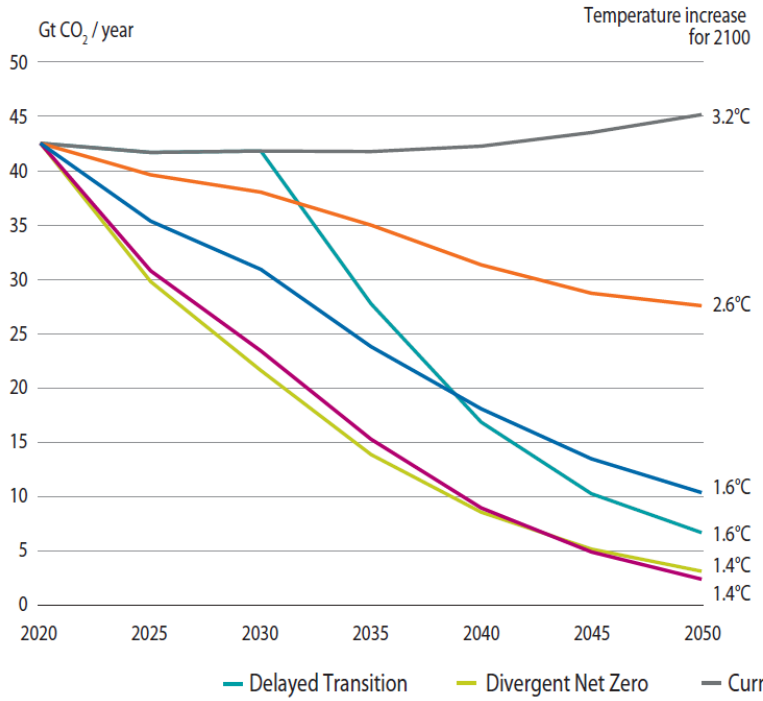
Scenario narratives

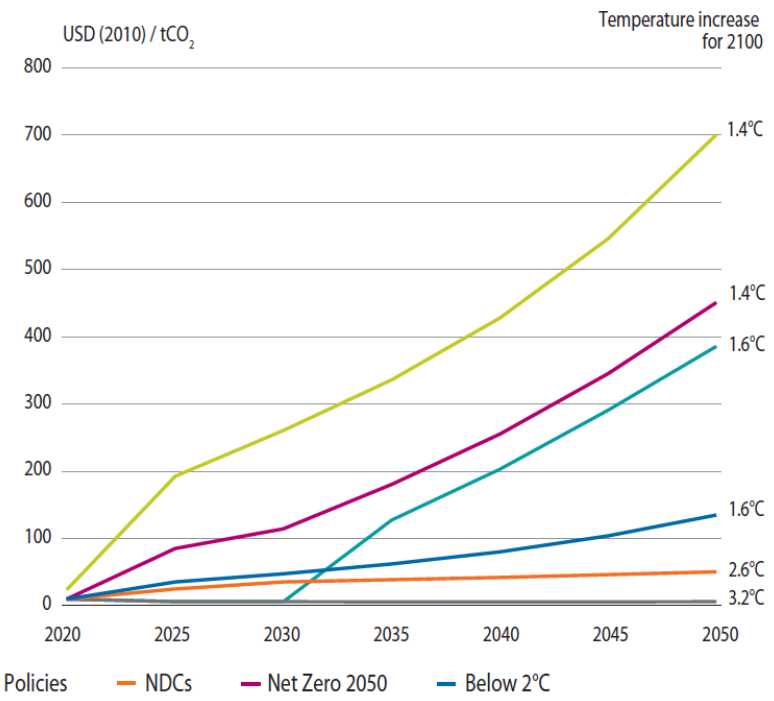
Each NGFS scenario explores a different set of assumptions for how climate policy, emissions, and temperatures evolve, and provides impacts on macro-financial variables.

CO_2 emissions by scenario



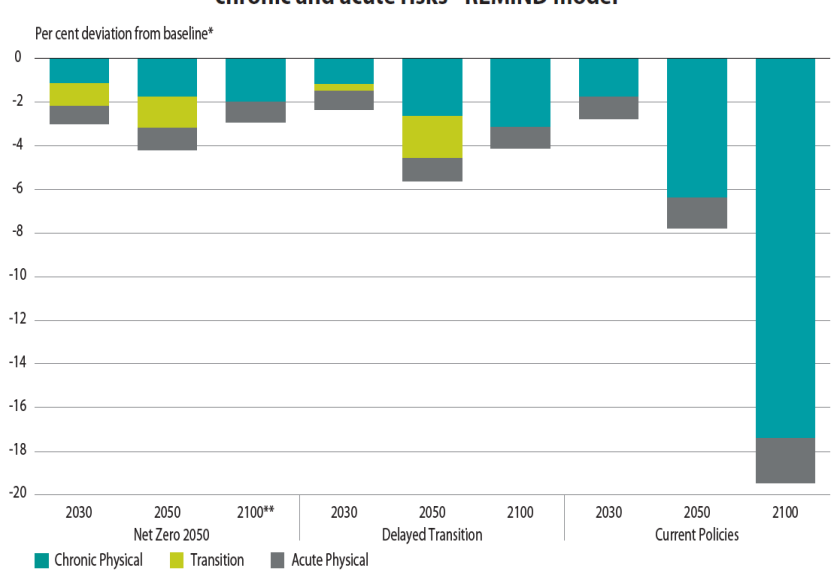
World aggregates mask strong differences across sectors and jurisdictions. Regionally and sectorally granular information is available on the IIASA database. End of century warming outcomes shown. 5-year time step data. Source: IIASA NGFS Climate Scenarios Database, REMIND model.

Carbon price development



The chart represents shadow carbon prices, which is a measure of policy intensity. Carbon prices are weighted global. Regionally and sectorally granular information is available on the IIASA database.
Source: IIASA NGFS Climate Scenarios Database, REMIND model.

GDP deviation due to transition, chronic and acute risks - REMIND model



* The NiGEM baseline is a hypothetical scenario with no transition nor physical risk
** Economic impacts are modelled out to 2050. To obtain an estimate of impacts in 2100, we took the estimate of physical risk impacts based on the damage function and assumed no transition risk impacts at this point (i.e., the GDP loss is solely due to physical risk).
Source: IIASA NGFS Climate Scenarios Database, NiGEM model (REMIND inputs).

Next objectives for the NGFS Scenarios

Phase IV objective: improve the design of the NGFS Scenarios and promote their wide use by a broad range of stakeholders.

Technical objectives

Improve scenarios

Update scenarios

- Increase **sectoral granularity** and **geographical coverage**, especially in emerging economies
- Manage the trade off between **usability and complexity** of scenarios
- Introduce **short-term scenarios** (including higher-frequency data) that could be best used for scenario analysis and stress-tests
- Better represent acute **physical risk**
- Update based on latest data and models

Strategic objectives

Make NGFS scenarios an international standard

- **Improve usability** and limit complexity of the scenarios ("off-the-shelf")
- Improve transparency and provide users with **methodological guidance**
- **Broaden the user base** of scenarios (beyond central banks/supervisors to also private institutions, academics), and **increase range** of applications of NGFS scenarios

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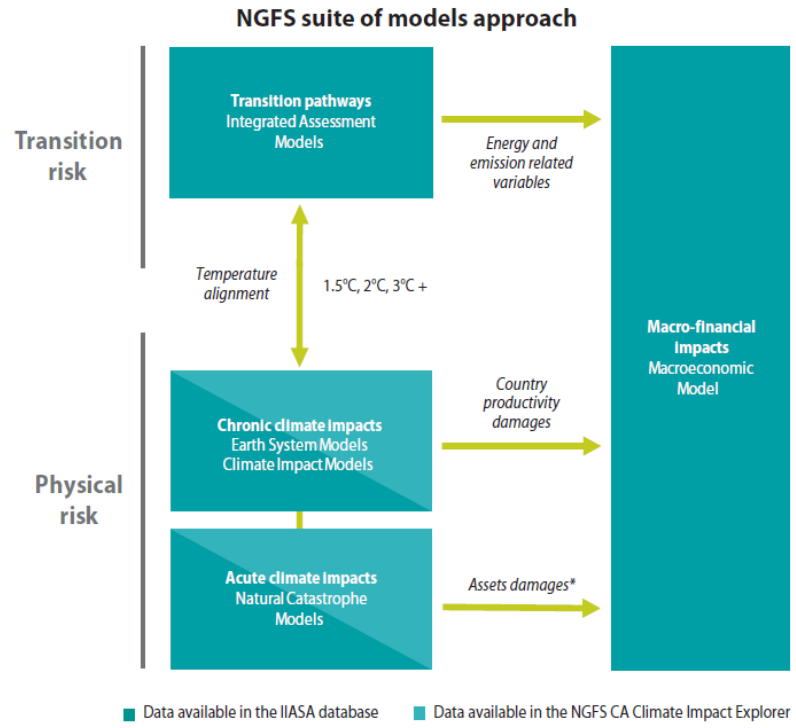
Thanks for listening

Annex

Models, data and navigation tools

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

- Transition and economic variables are made available in the NGFS Scenarios Explorer
- Climate variables can be explored through the NGFS Climate Impact Explorer
- Key data and resources can be explored interactively on the NGFS portal
- Last year, the scenarios were accompanied by several **side documents**:
  - A note exploring the effects of the current energy crisis, and how they relate to the NGFS scenarios
  - A sensitivity analysis to fiscal and monetary policy
  - A guide for assessing physical climate risks



The current acute physical impacts include GDP effects from extreme events, but exclude capital stock effects.

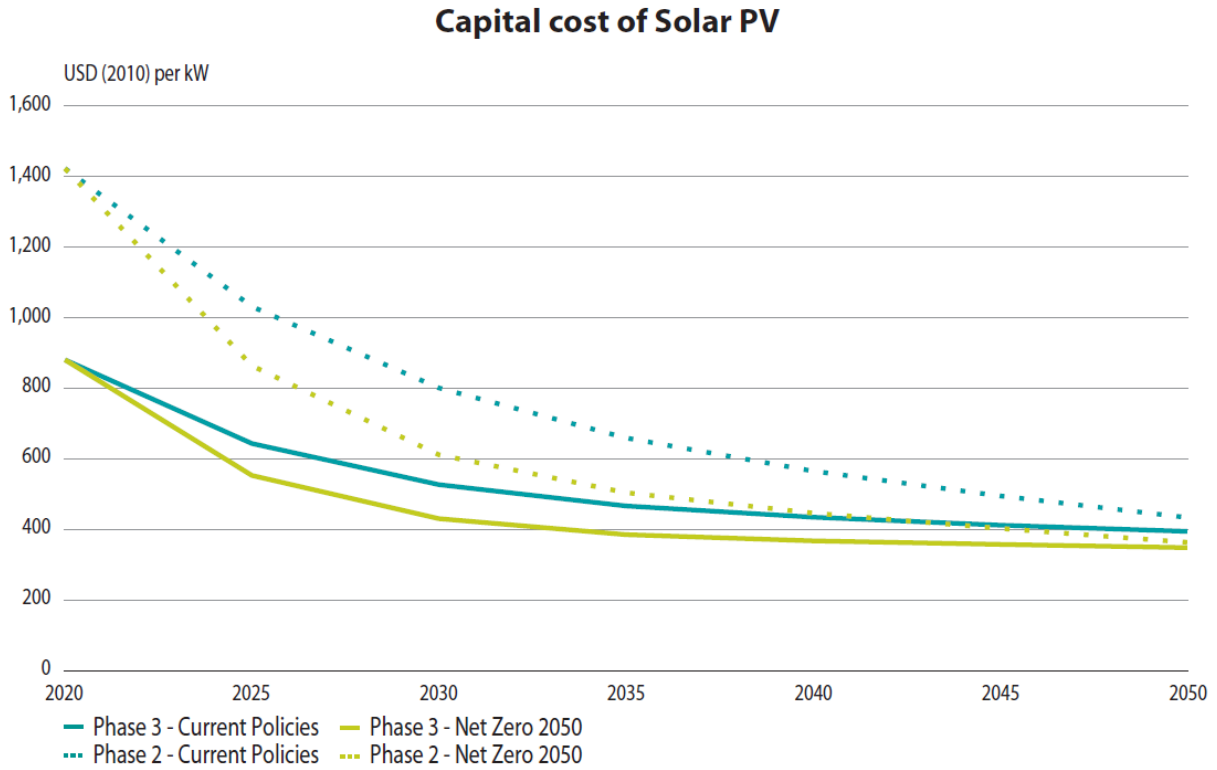
What's new in phase III NGFS Scenarios?

Data, commitments and model updates

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

NGFS scenarios now reflect:

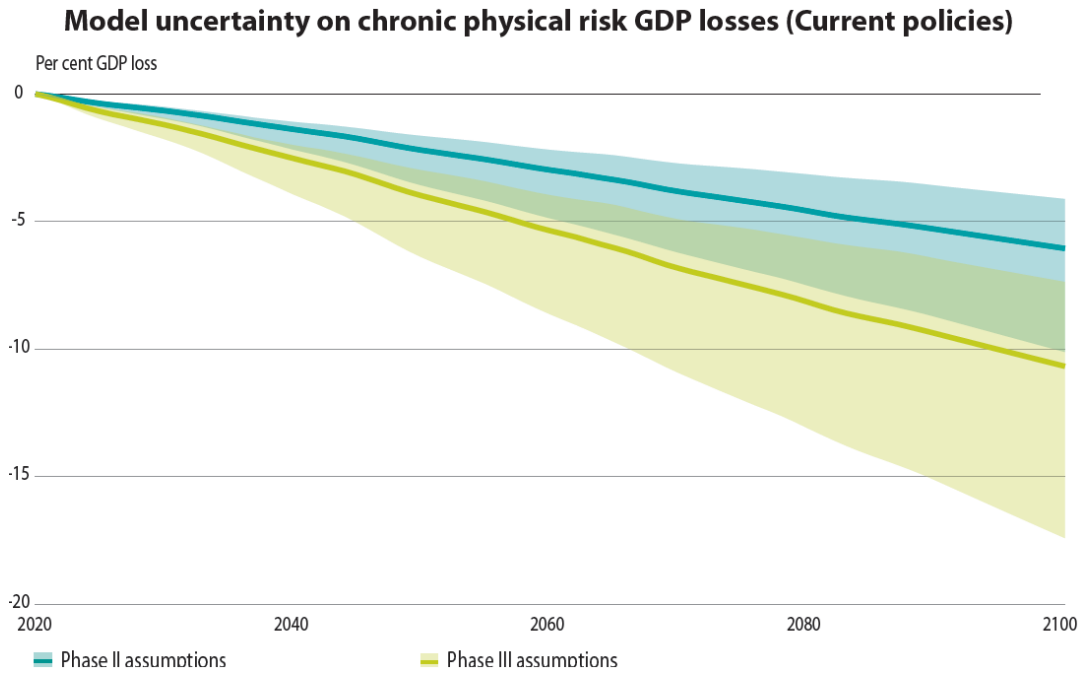
- Country-level **commitments** to reach net-zero emissions made at COP26 (Nov. 2021)
- Latest trends in **renewable energy technologies** (e.g. solar and wind), and key mitigation technologies
- Data for GDP and population based on the latest snapshot of the **IMF World Economic Outlook 2021**, including COVID-19



Source : IIASA NGFS Climate Scenarios Database, REMIND model.

Improved modelling of physical risks

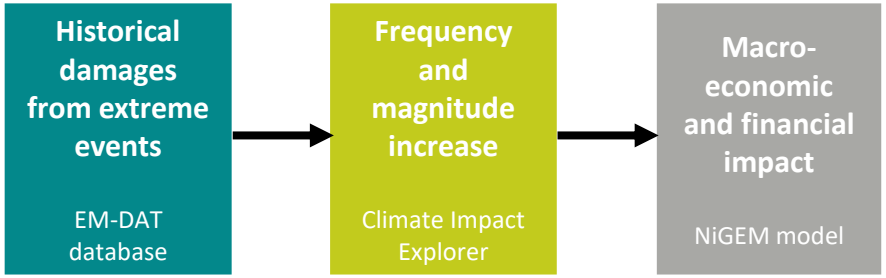
Estimates of GDP losses from chronic risks now more account for model uncertainty.



Source: IIASA NGFS Climate Scenario Database – Kalkuhl and Wenz (2020) damage function with temperature trajectory resulting from REMIND model emissions. The baseline is scenario (from IAM outputs) with no transition nor physical risk.

Acute physical risks are included for the first time via the integration of stochastic shocks.

Modelling of acute physical risk



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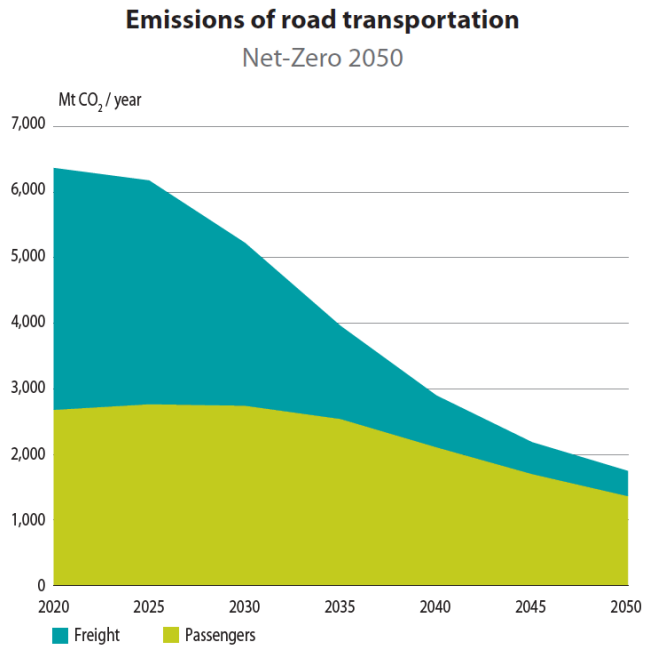
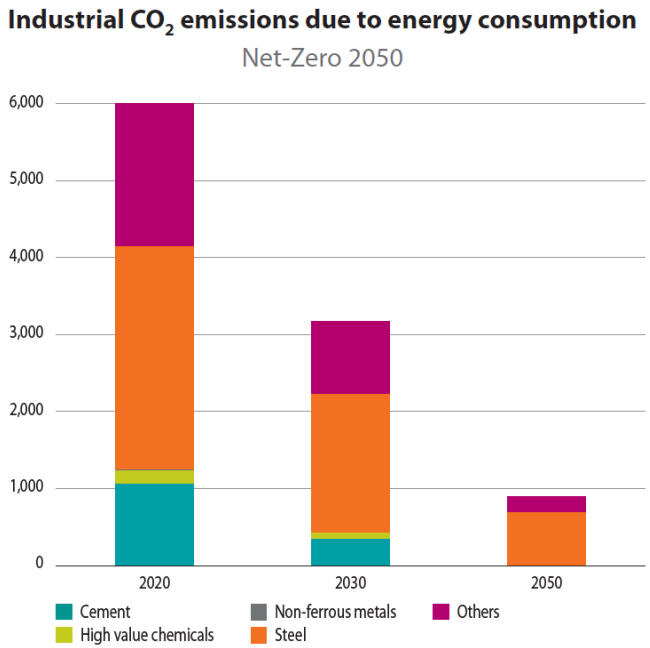
Increased sectoral breakdown

Transition risks are represented with increased granularity in certain sectors.

- Better representation of **transport and industry sectors** within REMIND and GCAM
- Increased granularity for **industry sector** within MESSAGE
- **Pilot project with the G-Cubed model**, to improve the sectoral breakdown
  - Results not integrated in the Phase III package, but published



Source: IIASA NGFS Climate Scenarios Database, REMIND model.



Source: IIASA NGFS Climate Scenarios Database, MESSAGE model.

Main results of phase III NGFS Scenarios

Key macrofinancial results

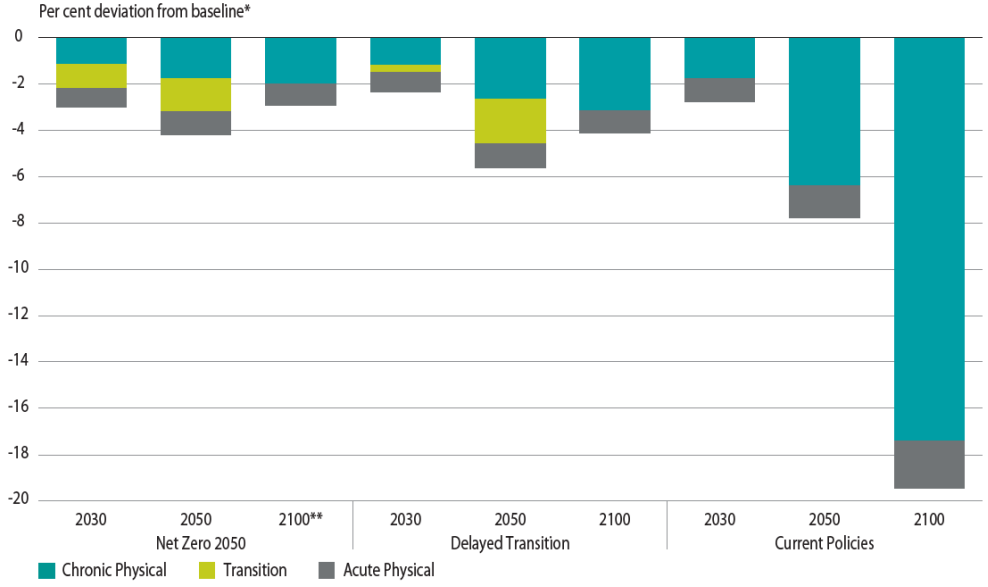
Gross domestic product (1/2)

Scenarios differ markedly in their economic impact, with significant uncertainty in the size of the estimates and variation across regions.

- **Transition risk** slightly but negatively affects world GDP in **Net Zero 2050**
- Negative GDP impacts from **transition risk** are more significant in **disorderly scenarios**
- GDP losses from **physical risks** scale with the change in temperatures in the three scenarios

Note: Impacts on GDP incorporate some of the near-term impacts from COVID-19, but do not yet account for the war in Ukraine

GDP deviation due to transition, chronic and acute risks - REMIND model



* The NiGEM baseline is a hypothetical scenario with no transition nor physical risk
** Economic impacts are modelled out to 2050. To obtain an estimate of impacts in 2100, we took the estimate of physical risk impacts based on the damage function and assumed no transition risk impacts at this point (i.e., the GDP loss is solely due to physical risk).
Source: IIASA NGFS Climate Scenarios Database, NiGEM model (REMIND inputs).

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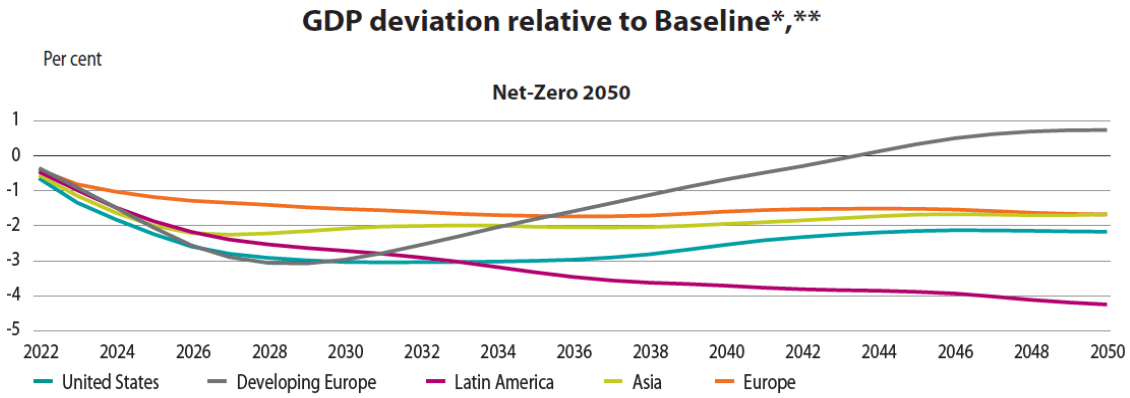
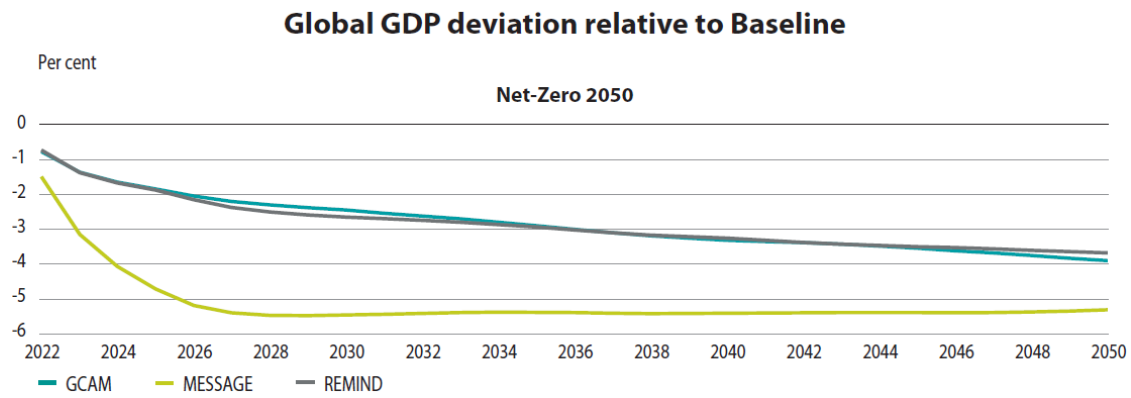
Gross domestic product (2/2)

NIGEM provides economic impacts per country and region, giving estimates of country's exposure to transition and physical risks, calibrated based on inputs from the three IAMs.



Source: IIASA NGFS Climate Scenarios Database, NiGEM model (REMIND inputs).



The NiGEM baseline is a hypothetical scenario without transition nor physical risk.
** Country-level GDP includes transition and chronic physical risk only.
Source: IIASA NGFS Climate Scenarios Database, NiGEM model (REMIND inputs).

- Heterogeneous impacts across **countries and regions**, driven by different transition and physical risk profiles
- Heterogeneous impacts across **models**, driven by model structure and assumptions

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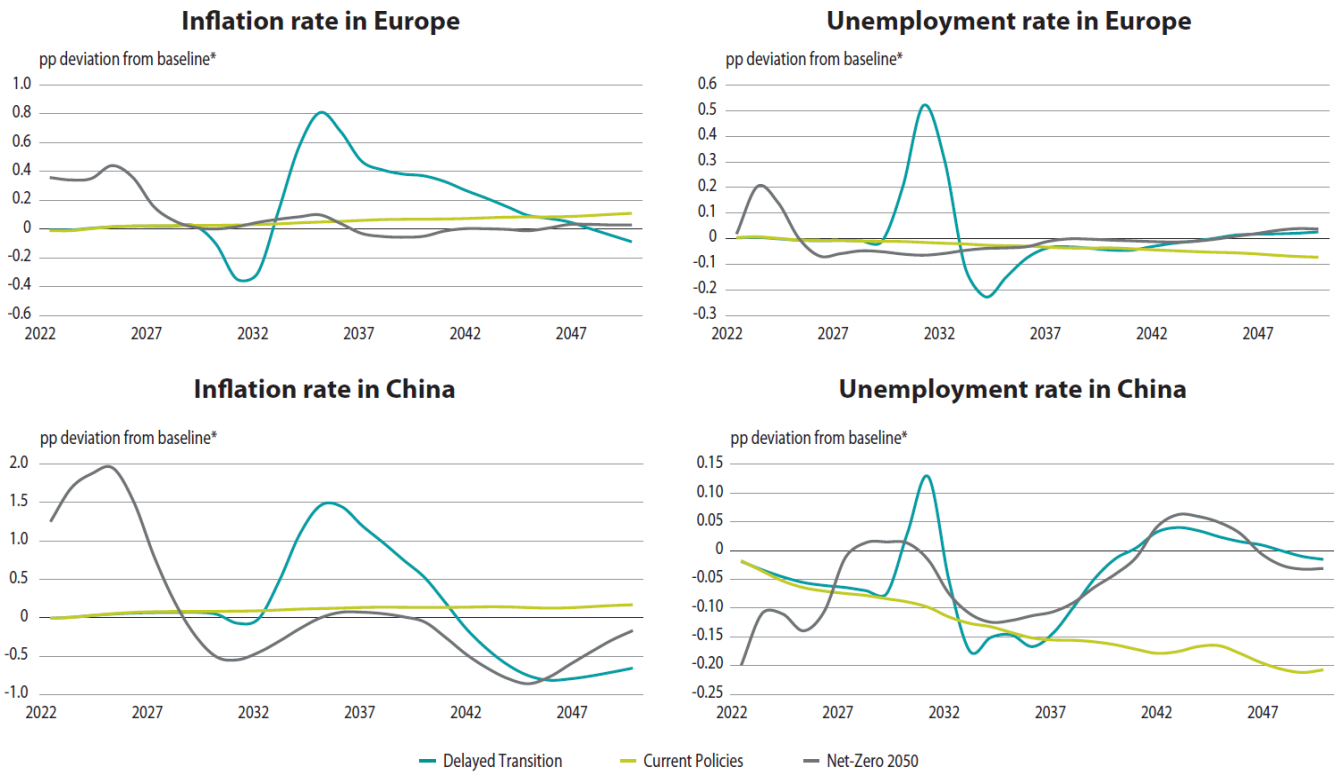
Inflation and unemployment

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

- Modest and temporary increase in **inflation** and **unemployment** in transition scenarios
- In some scenarios this leads to a potential **monetary policy tradeoff**

Note: More research needed on the impact of green transition on inflation and/or unemployment



* The baseline is a hypothetical scenario with no transition nor physical risk .
Sources: NiGEM based on REMIND-MAgPIE IAM data and damage estimates from Kalkuhl & Wenz (2020).

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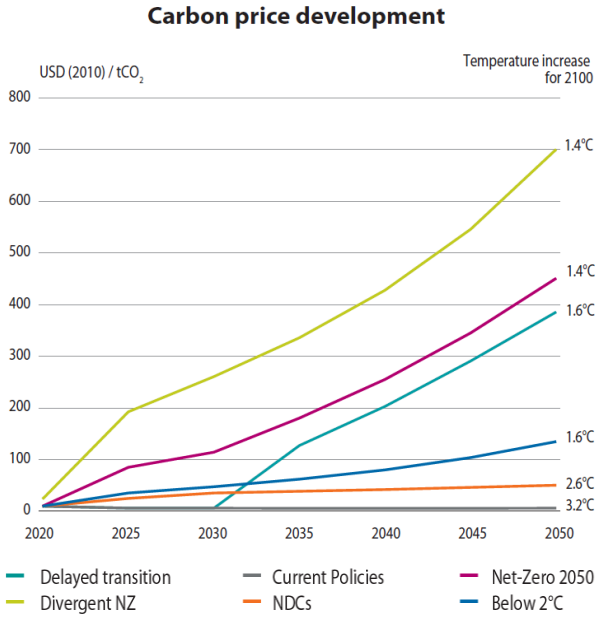
Main results of phase III NGFS Scenarios

Transition and physical risk

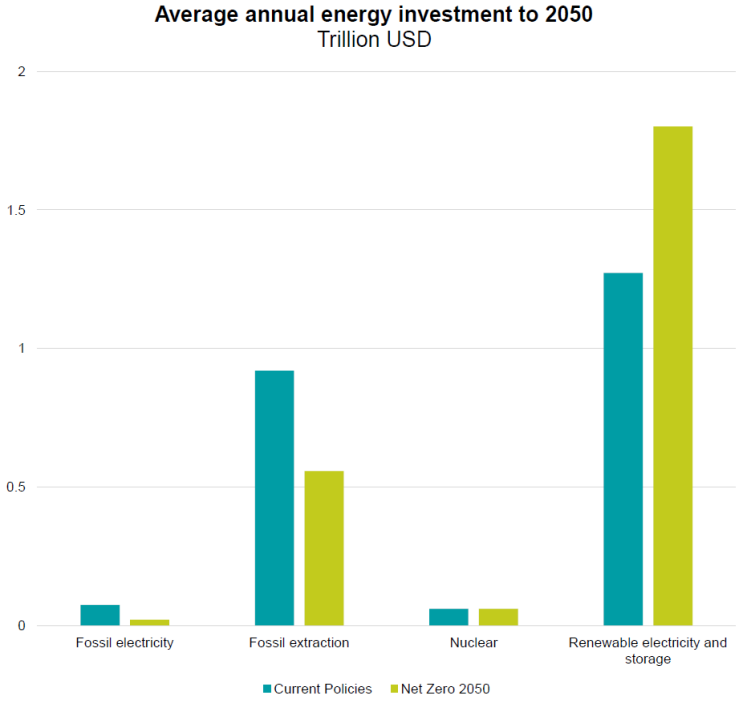
Emissions price, CDR and energy investment

Key indicators of the level of transition risk are emissions price, availability of Carbon Dioxide Removal (CDR) technologies and energy investments.

- Higher **emissions price** implies more stringent policy: a carbon price of around $200/ton would be needed in the next 10y to get to net zero by 2050
- Significant **investment** needs to be **directed towards green energy** in the coming decades to achieve net zero
- The transition path also depends on the availability and deployment of **carbon dioxide removal** (see next slide)



The chart represents shadow carbon prices, which is a measure of policy intensity. Carbon prices are weighted global. Regionally and sectorally granular information is available on the IIASA database.
Source: IIASA NGFS Climate Scenarios Database, REMIND model.



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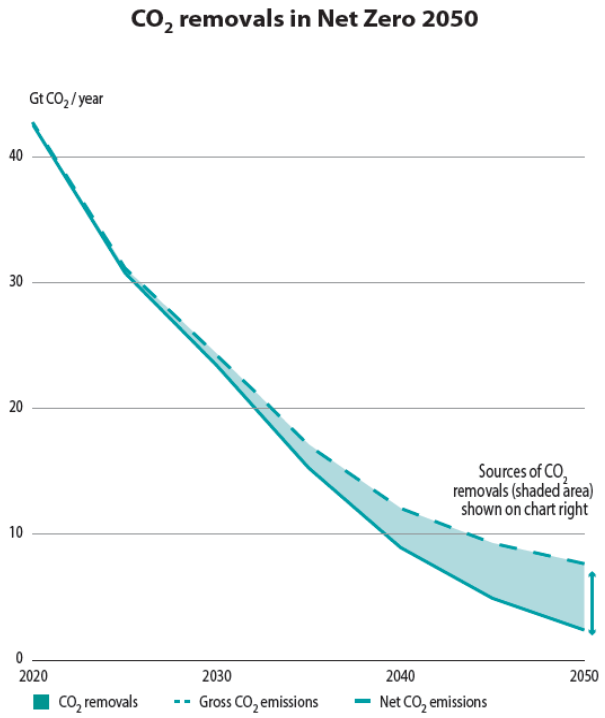
Carbon Dioxide Removal

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.

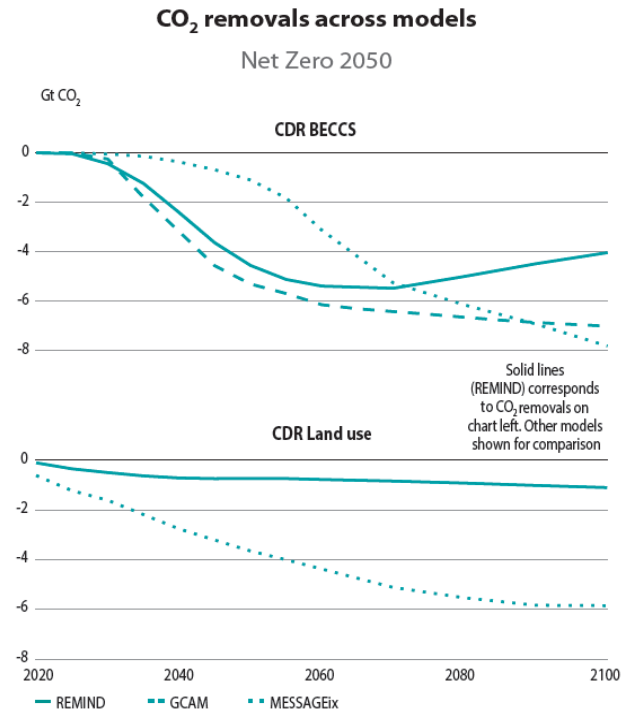
- **Carbon Dioxide Removal** (CDR) involves removing carbon from the atmosphere through increasing forest cover and soil sequestration or growing crops for bioenergy

- If deployed effectively, lower warming outcomes could be achieved, or targets could be reached sooner

- The NGFS scenarios assume **low to medium availability of these technologies**, with differences across models and countries depending on cost and availability assumptions



Source: IIASA NGFS Climate Scenarios Database, REMIND model.

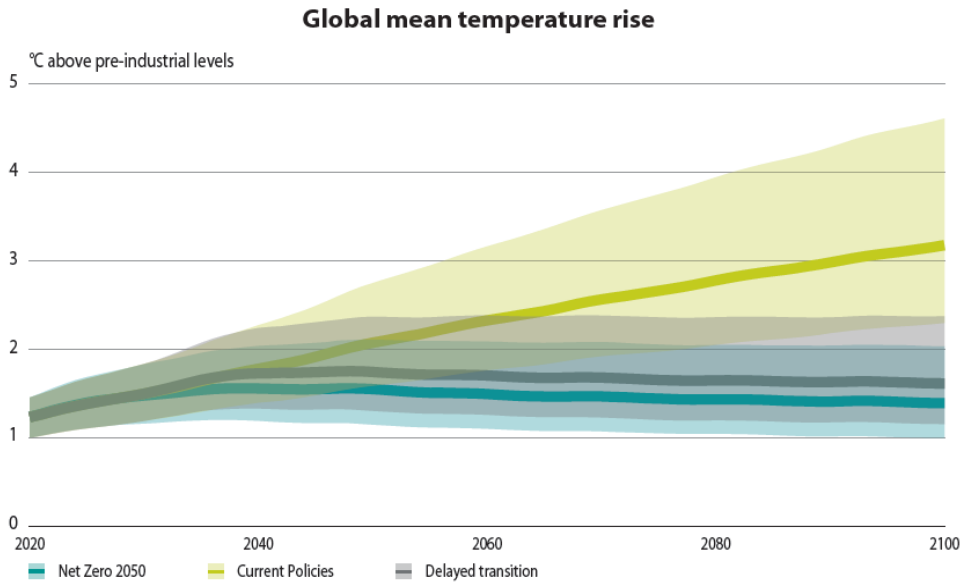


Source: IIASA NGFS Climate Scenarios Database

Temperature rise and GDP losses

Mean temperatures rise in all scenarios, exceeding 3°C in Current Policies. Changing climate conditions affect physical labour productivity and lead to severe and irreversible impacts.

- **Climate goals** aim at limiting the rise in global mean temperatures to **below 1.5°C or 2°C** by the end of the century
- This does not occur in the Current policies scenario, leading to a temperature rise above 3°C and severe irreversible impacts
- Temperature changes lead to **chronic changes in living conditions** affecting health, labour productivity, agriculture, ecosystems and sea-level rise; and also **changes in the frequency and severity of severe weather events**
- Estimates suggest a **global GDP losses of up to 18%** relative to a prior trends baseline in the Current Policies scenario, with much higher losses in tropical regions



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