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# CRU Climate Change Scenarios Report

A scenario-based outlook for macroeconomics, heavy industry and key metals

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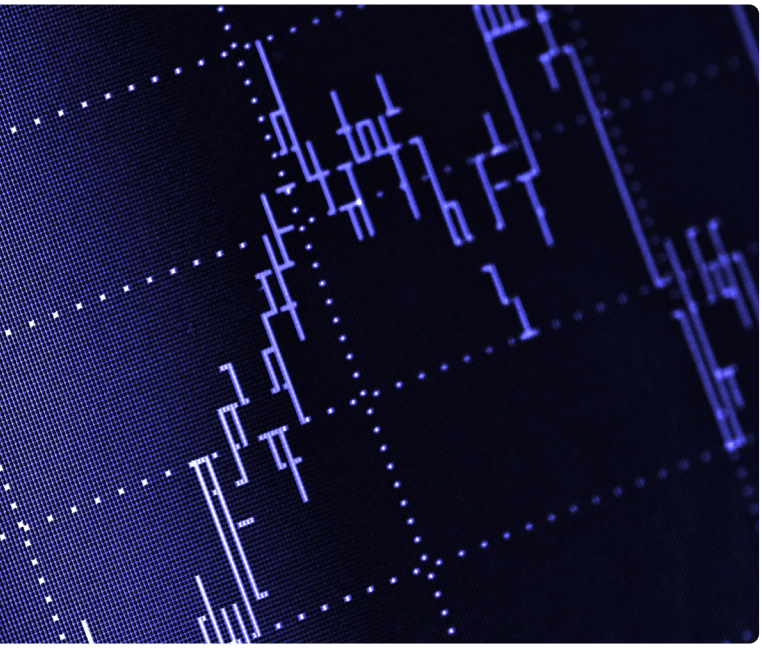
# Contents

Click on a heading to jump to the corresponding section

# Executive introduction

The world is at a critical juncture regarding climate action, with consequences that will fundamentally reshape commodity markets and industrial operations. The effects of global warming are becoming increasingly evident through more frequent and extreme weather events, including unprecedented heatwaves, devastating floods and powerful hurricanes that disrupt supply chains and damage infrastructure.

Heavy industries, such as manufacturing, construction, and energy production, are particularly vulnerable to both physical and transitional climate change risks. Extreme weather events can disrupt operations, infrastructure and supply chains. Rising sea levels threaten coastal facilities, while changing precipitation patterns affect water availability for industrial processes. Extreme heat poses direct threats to industrial operations by reducing worker productivity, forcing operational shutdowns and increasing cooling costs for machinery and facilities. Additionally, rising temperatures can increase energy demand and impact the reliability of energy supply. These risks can lead to significant economic losses, operational challenges and regulatory burdens for heavy industries.



Furthermore, the transition to a low-carbon economy poses significant multifaceted challenges. These include elevated operational costs resulting from stringent environmental regulations and carbon pricing mechanisms; increased exposure to stranded asset risk as energy markets shift toward renewables; and vulnerability to ongoing market disruptions. The accelerating shift toward renewable energy is expected to suppress demand for fossil fuels and related materials, creating structural changes in market dynamics and impacting long-term profitability.

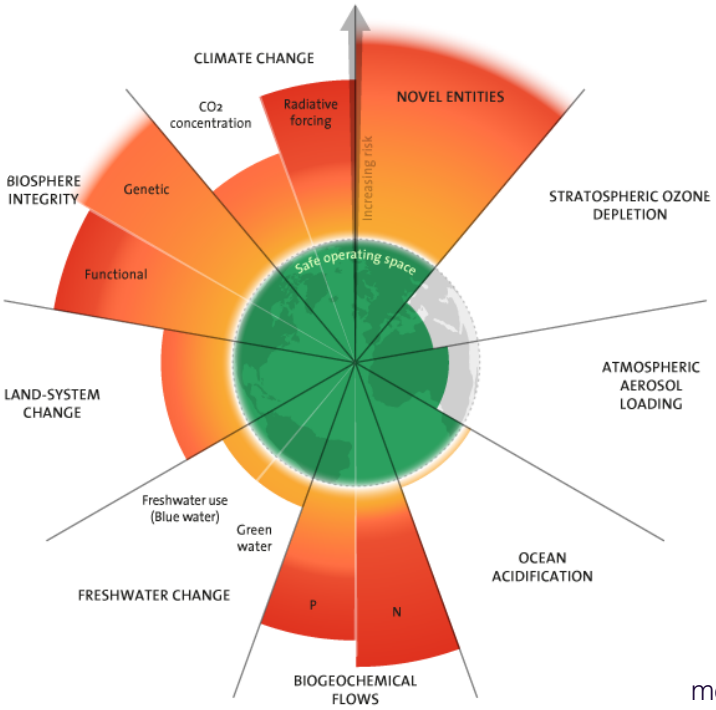
The Paris Climate Agreement established the goal of limiting global temperature rise to well below +2°C above pre-industrial levels, preferably to +1.5°C, to avoid the worst effects of climate change. However, global temperatures are already expected to consistently exceed +1.5°C by the early to mid-2030s, and the window for limiting warming to +2°C is rapidly closing. Scientific research indicates that crossing the +1.5°C threshold may trigger long-term changes to planetary systems, some of which will be potentially irreversible.

Current evidence shows that seven out of nine planetary boundaries have been crossed due to human activity – climate change, biodiversity loss, altered biogeochemical cycles (phosphorus and nitrogen), land-system change, freshwater use, novel entities (the introduction of synthetic chemicals, plastics etc.) and ocean acidification. Crossing these boundaries increases the risk of cascading effects and abrupt changes to the Earth's systems, with significant implications for economic stability and human wellbeing.

## 7 out of 9 planetary boundaries have been crossed

Despite growing recognition of climate change as a serious global threat, policy action to address it has been insufficient and, in fact, has slowed over the past few years. Several factors have contributed to this slowdown. Economic downturns, geopolitical tensions, and the rise of populist and nationalist movements have diverted attention and resources away from climate initiatives.

In the US, the election of Donald Trump has compounded this trend. With his administration choosing to roll back on existing climate policies and environmental protections, it is deprioritising climate action in favour of domestic economic growth and energy independence, including support for increased fossil fuel production.




*SOURCE: Azote for Stockholm Resilience Centre, based on analysis in Sakschewski and Caesar et al. 2025*

In addition, the interconnectedness of climate change solutions, the complexity of transitioning to low-carbon economies and the associated costs have created significant challenges in developing and implementing effective policies on a global scale. These obstacles have hindered our progress in addressing the climate crisis and underscore the urgent need for more ambitious and coordinated action.

## Three ways forward

Looking ahead, three broad pathways emerge for global climate action, each with different implications for commodity markets:

- **Accelerated Action:** Rapid implementation of emission reduction measures and climate policies will help limit temperature increases and associated climate risks. However, this requires significant near-term investment and market transformation.
- **Current Trajectory:** Continuation of gradual progress under existing policies and corporate commitments, which remains insufficient to meet climate goals and results in elevated climate risks and temperature growth of +2.5°C to +3°C.
- **Delayed Action:** Limited climate action allows emissions to continue rising, leading to temperature growth well above +3°C, surpassing pre-industrial levels and presenting high climate risks, requiring extensive future adaptation measures.

Escalating climate risks will necessitate increasingly extensive and costly adaptation measures across all sectors. Without decisive action to reduce greenhouse gas emissions, we risk irreversible damage, with consequences spanning centuries.

## Scenario analysis framework

The systemic risks posed by climate change (and the policies implemented to tackle them) will impact every industry, market and economy in varying ways and at different times, creating both risks and opportunities. This report examines **three climate scenarios** that reflect these pathways and their potential impacts on economies and the heavy industry.

Our **central scenario** reflects the current trajectory, where global decarbonisation efforts improve, but ultimately fall short of the ambitious goals set out in the Paris Agreement. Despite progress made in certain regions, the collective actions of nations are insufficient to prevent global temperatures from rising between +2.5°C and +3°C. This temperature increase leads to substantial damage to ecosystems and economies worldwide, with developing countries bearing the brunt of the impacts.

The **below +2°C scenario** explores the accelerated action pathway, where intensified global cooperation and rapid decarbonisation efforts successfully limit global temperature increases to below +2°C by 2100. While this scenario avoids the most severe impacts of climate change, economic growth still faces headwinds from the effects of rising temperatures, which will manifest in the form of more frequent extreme weather events and disruptions to essential industries.

The **high emissions scenario** represents the delayed action pathway, where limited climate efforts result in temperature increases exceeding +3°C relative to pre-industrial levels by 2100. This will result in catastrophic changes in weather and ecosystems, with global Gross Domestic Product (GDP) declining dramatically as countries struggle to adapt to extreme conditions.

These climate change scenarios offer a more granular and realistic perspective on the energy transition, which is suitable for use in transition planning and risk management for industry and commodity markets. Unlike conventional scenarios that rely on top-down assumptions, our scenarios are dynamic and adaptive, combining bottom-up industry analysis with big picture views on the drivers of decarbonisation – including information on market trends, policy developments, technology innovations and actions taken at the facility level to decarbonise globally.

By incorporating expertise in hard-to-abate sectors and the economics of clean technologies, we ground our scenarios in realistic assumptions about technology deployment and policy evolution. By examining the environmental, social and economic dimensions of the transition holistically, we provide stakeholders with an actionable roadmap to navigate climate uncertainty and drive the transformation toward rapid decarbonisation and sustainable energy systems.

***Mark Jeavons**, Head of Sustainability, Economics & Sustainability, CRU*

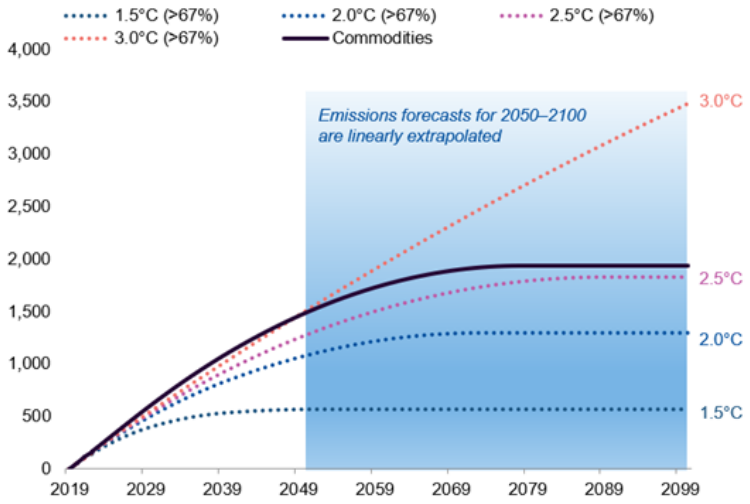
# The state of play on climate action

Since the Paris Agreement in 2015, addressing climate change has become a significant area of focus, discussion and policy activity for national governments and multilateral organisations, such as the EU and UN. Despite this, emissions have continued to rise every year since – with the exception of 2020, when the Covid-19 pandemic saw economic activity, transport and energy use fall sharply. This proved to be short-lived, with emissions returning roughly to the pre-pandemic trends thereafter. This matters because the cumulative level of GHG in the atmosphere is what causes climate change, not the current flow of emissions. There has been much focus by campaigners and political leaders on commitments to reach net zero emissions by a particular date. However, what ultimately matters is the cumulative emissions to net zero. The longer it takes for emissions to begin falling, the greater the build-up of GHG in the atmosphere.

Had emissions begun falling steadily from when the Paris Agreement was signed in 2015, then further steady progress towards net zero by 2050 would have been sufficient to limit temperature increases to +1.5°C above pre-industrial levels by 2100. However, the rising trend in emissions since 2015 means that limiting temperatures to +1.5°C would need to take an extremely rapid (and we believe, unrealistic) fall in emissions. It should still be possible to limit temperature increases to less than +2°C, but even this will require much greater action than what has already been announced by governments. Given the time needed for many major investments in the energy system, decisions need to be made soon.

CRU provides unparalleled visibility of GHG emissions across commodity value chains, leveraging asset-level data to deliver granular insights. Our coverage encompasses the complete metals value chain, power generation, light vehicles and cement production. This translates to visibility over approximately 60% of total global emissions and 90% of industrial emissions.

Commodity emissions are on a >+2.5C pathway through 2100




DATA: CRU Asset Platform – emissions, CRU Power Transition Service, CRU Long-term Steel Outlook, CRU Low-emissions Hydrogen and Ammonia Market Outlook. UNEP Emissions Gap Report 2024, The IPCC Sixth Assessment Report (AR6) – Longer Report and IPCC AR6 summary for policy makers; NOTE: commodity emissions have been normalised to 2019 global GHG emissions so that the emissions trajectories can be compared directly with each other and with the IPCC global heating scenarios that are also included in the chart.

Based on a bottom-up view of the most likely path of decarbonisation in each of these sectors, emissions from these commodities are on a pathway consistent with warming of between +2.5°C and +3.0°C (see the chart below from our **Energy Transition and Decarbonisation Service**). Although in this scenario we expect emissions to fall significantly by 2050, particularly in the power sector, early progress remains too slow to stay within the +2°C carbon budget. This view of emissions forms the basis of our **central scenario**. Such a level of emissions will lead to large-scale economic damage, particularly to developing countries. We explore these impacts later in this report.

# Our climate change scenario narratives

This section sets out the narrative that drives each of our scenarios. The table below summarises each scenario across a number of dimensions. The rest of the sections unpack each scenario in more detail.

| | <+2C | Central | High emissions |
|---|---|---|---|
| **Political** | National governments prioritise green agenda as the costs of climate change become increasingly clear. Significant international co-operation between governments, e.g. funding. | Governments continue to introduce green policies, but they are concentrated in areas where they overlap with other concerns, such as energy security and industrial policy. International cooperation is more fragmented and competition-driven. | Governments scale back green policies. International cooperation is limited, with only periodic bursts of cooperation where shared risk is more obvious. Growing interstate tensions over resources and migration. |
| **Economic** | Transition costs act as a moderate drag on growth, as does climate change itself, but the most serious economic impacts are avoided. | Climate change causes severe economic damage, particularly to developing countries. Global growth slows significantly by mid-century. | By mid-century, large falls in GDP are experienced by developing countries, along with significant falls in developed countries. |
| **Social** | As the impacts of climate change become increasingly clear, pressure from voters and civil society for climate action builds. | Voter and public opinion fragments between those wanting faster climate action and those protesting the cost. | A widespread backlash against the cost of decarbonisation weakens support for climate action. |
| **Technological** | The cost of clean technologies falls rapidly through stronger R&D and learning-by-doing, while new technologies diffuse rapidly. | Clean technology costs fall somewhat, but economic nationalism and fragmentation limits progress. | Little technological progress is made in green technology, and costs remain high, relative to fossil fuel technologies. |
| **Legal** | Green regulation – on both behaviour and data/disclosure – becomes increasingly important for firms to navigate. | Green regulation continues to develop but is limited by political backlash. Firms have to navigate an increasingly complex web of geopolitical trade and investment decisions. | Green regulation is rolled back and poorly enforced. |
| **Environmental** | There is some increase in extreme weather events, and a moderate rise in sea levels, but most 'tipping points' are not triggered. | Significant rise in extreme weather, and a number of ecological tipping points are breached. Food and water stress increases. | Wholesale collapse of many ecosystems. Severe and widespread increases in food and water insecurity. |
| **Carbon markets** | Strong collaboration on carbon markets and agreement on Article 6 allows carbon offsets to be traded internationally, using common standards for brokers. ETSs mature rapidly and global carbon prices converge on European levels. Subsidies also rise, helping to incentivise a rapid reduction in emissions. | Regions adopt their own approaches to decarbonise their economies, with some progress on operationalising Article 6. However, international trading of carbon offsets is limited.<br><br>ETSs mature at a slower pace and the progress on new regional ETSs is slow, with a more subdued rise in carbon prices. | There is limited agreement on carbon markets and incentivising emission reductions. Effective carbon prices remain low.<br><br>Delayed progress or reversal in developing carbon markets. |
| **Power transition** | Renewables reach almost 80% of global electricity generation, and zero-carbon 95% by 2050. Demand for electricity expands rapidly due to a significant increase in electrification and strong economic growth. | Renewables reach around two-thirds of global electricity generation, and zero-carbon over 80% by 2050. Electrification and economic growth pushes up power demand, but some key difficult-to-abate sectors (steel, cement) continue to produce significant emissions. | The zero-carbon share of electricity generation marginally increases from 43% in 2024 but remains below 60% by 2050. |

# Central scenario

### Global climate action remains fragmented

In our **central scenario**, global action on climate change remains incremental, with emission reductions falling short of the Paris Agreement targets. While some regions make progress, the lack of coordinated, decisive action prevents the world from limiting temperature growth to safe levels. As a result, global temperatures are projected to increase by over +2.5°C above pre-industrial levels by 2100 but remain below +3°C of warming. This temperature increase causes significant harm to ecosystems and economies worldwide, with developing nations facing the most severe consequences due to their heightened geographic vulnerability and limited resources for adaptation.

### National interests drive climate policies

Governments continue to pursue green policies, but primarily when they align with national strategic priorities, such as energy independence, economic growth or national security. This fragmented approach, shaped more by domestic interests than a unified climate commitment, results in varying levels of climate action. Some countries focus on short-term economic gains, while others – driven by market demands or domestic incentives – invest more in clean technologies. Without a cohesive global framework, these national policies fall short of achieving impactful emission reductions and effective adaptation efforts.

### Different regional policy approaches under the central scenario

Green policies are shaped more by national interests than a unified climate commitment.

In the **United States**, the government prioritises fossil fuel independence and deregulates environmental protections to lower energy costs, aiming for an economy that depends less on foreign oil, with weaker investment in clean energy.

Meanwhile, the **European Union**, despite economic pressures, continues to champion renewable energy and imposes emission targets to boost energy security and innovation in green industries.

In **China**, industrial policy encourages rapid advancements in renewable technology, which strengthens its manufacturing base and global trade influence, while achieving energy independence. However, large-scale consumption of domestically produced fossil fuels continues.

Most **developing nations** proceed with clean energy as it aligns with economic growth but rely heavily on international support to make significant changes. Continued economic growth – at least in the earlier part of the forecast horizon – drives continued growth in energy demand.

This patchwork of national policies leads to sporadic progress, where some regions see substantial emission reductions while others remain stagnant, ultimately weakening the collective impact against climate change.

### Climate regulation continues to evolve in response to growing climate risks

Climate-related regulations continue to evolve, but progress is tempered by political resistance and shifting priorities. While many governments implement stricter legal and regulatory frameworks to encourage climate mitigation and adaptation, adoption and effectiveness of these policies remain uneven, with enforcement and compliance varying widely across regions.

Firms face growing challenges as they navigate a complex and often conflicting landscape of geopolitical trade restrictions and investment requirements related to green initiatives. Despite regulatory advances, environmental degradation persists, with biodiversity loss and ecosystem disruptions becoming more severe.

As global temperatures rise along a +2.5°C to +3°C path, extreme weather events – such as storms, floods, and heatwaves – become more frequent and intense, causing widespread economic disruption. Infrastructure damage, reduced agricultural yields and supply chain interruptions create a severe drag on global economic growth. Developing nations, already facing limited resources, are hit the hardest as adaptation costs divert funds from essential development projects, thereby further stalling economic progress. Forced migration, due to regions becoming less habitable, adds to social and economic strain, increasing competition for resources and escalating geopolitical tensions. By mid-century, these climate-related disruptions are expected to significantly slow global GDP growth, as population and productivity declines intensify.

### Climate change and transition pressures deepen societal divisions

Climate impacts and transition pressures exacerbate social divides both within and across nations. In developing regions, displaced populations face water scarcity, food insecurity, and loss of livelihoods, leading to increased migration. Our analysis suggests that climate change on this scale will result in ~56 million additional people being forced from their homes between now and 2050. Most of this migration will be within countries and regions, creating economic dislocation and raising the risk of conflict. However, millions of people will also seek to move to areas less severely affected by climate change, such as Europe and North America. This will make immigration an increasingly topical issue in developed countries. Public opinion in developed countries will become increasingly polarised – some demand faster climate action, while others resist due to perceived economic costs, straining social cohesion and governance.

### Technological innovation supports gradual take-up of clean technologies

Technological progress in clean energy and climate adaptation continues, but it is modest and uneven. Economic nationalism and fragmented global cooperation limit investment and knowledge-sharing, slowing the decline in costs for key technologies such as renewable energy, energy storage and carbon capture. Although clean technologies continue to generate an increasing percentage of the world's electricity rising from 43% in 2024 to 56% by 2030 and 86% by 2050, it is insufficient to fully offset emissions from fossil fuels.

While global emissions begin to decline from 2025, they remain above 25 billion tonnes of $CO_2e$ in 2050, with net zero not expected until 2069.

Given the slow pace of emission reductions, carbon capture and removal technologies are increasingly deployed to remove $CO_2$ from the atmosphere to help offset sectors that are hard to decarbonise. While these technologies develop gradually, the lack of robust international collaboration limits large-scale deployment and keeps costs high, hindering their effectiveness. Overall, the technological evolution under this scenario is insufficient to fully mitigate climate impacts, leaving societies to contend with a high level of residual risk.

### Carbon market development and subsidies vary by region

The development of carbon markets remains slow and fragmented, with regions adopting their own decarbonisation pathways rather than aligning under a cohesive global framework. Although progress is made to operationalise Article 6 of the Paris Agreement, uneven implementation and limited transparency of decarbonisation projects undermine trust in the resulting credits. The poor implementation limits the effective international trading of carbon offsets and constrains the emergence of a high-integrity, unified market that could drive broader emission reductions.

While existing emission trading systems (ETS) mature, the introduction of new regional ETS frameworks is sluggish, and carbon prices rise slowly. As a result, the market's potential to incentivise large-scale decarbonisation is constrained, leaving industries and governments dependent on regional solutions that lack the scale needed for meaningful global impact, rather than leveraging a harmonised approach that could more effectively reduce emissions worldwide.

# Below +2°C scenario

Our below +2°C scenario outlines a pathway where global temperature rise is limited to +2°C above pre-industrial levels by 2100. Under this scenario, global efforts to decarbonise and mitigate climate change intensify, although it still falls short of the aggressive measures needed to meet the +1.5°C target. It offers a realistic pathway for achieving the Paris Agreement's goals, balancing the need for rapid global transformation with the practical constraints faced by governments, industries and societies.

### Emissions rapidly decline but physical climate risks persist

This scenario envisions a near-term peak in $CO_2$ emissions, followed by a significant decline, reaching net-zero emissions by 2050. While this pathway reduces the severity of physical climate risks compared to higher emissions pathways (such as our central and high emissions scenarios), it does not eliminate them entirely and the risks exceed those from a below +1.5°C path. Rising sea levels, heatwaves, droughts and extreme weather events will continue, albeit at a less severe pace. However, the most catastrophic outcomes, such as unchecked sea-level rise or widespread ecosystem collapse, are largely avoided.

The burden of these physical risks is disproportionately borne by vulnerable regions, particularly in tropical, polar and arid areas, which face challenges from heat stress, ice melting and water scarcity. In contrast, wealthier nations and regions with more resources experience more manageable impacts due to their capacity for adaptation. Despite the reduced risks, the delayed response in the climate system means that rising sea levels and extreme weather will persist for decades.

### Societal pressure to tackle climate change builds as weather events become more extreme

As climate impacts intensify, societal pressure mounts for decisive action. Public concern, fuelled by increasingly severe weather events, will cause a shift towards ambitious climate policies and economic transformation. The imperative to decarbonise the global economy becomes undeniable, prompting governments to implement far-reaching reforms aimed at reducing emissions and fostering resilience.

### Coordinated government action accelerates decarbonisation

In response, global policymakers strengthen international multilateral agreements to coordinate mitigation and adaptation strategies. Developed nations provide substantial financial and technological support to developing countries, motivated by economic interests and the need to avoid escalating climate risks.

Domestically, governments implement a comprehensive and coordinated set of actions to ensure emissions are rapidly reduced and societies adapt to the changing environment. Strong collaboration on carbon markets, supported by agreements under Article 6, enables the trading of carbon offsets across borders, with standardised protocols for brokers. Regional emission trading systems (ETS) mature quickly, and carbon prices rise to incentivise swift decarbonisation, converging toward European levels. Subsidies for clean technologies further support a swift reduction in emissions across hard-to-abate sectors.

### Climate regulations and standards tighten to deliver emission reductions

Climate regulations and standards become a cornerstone of global decarbonisation efforts. Governments implement stricter policies across industries, setting ambitious benchmarks for emission reductions and holding firms accountable for their environmental impact. These regulatory frameworks stimulate innovation by creating a predictable landscape for investment in low-carbon technologies.

In addition to mandates on operational behaviour, regulations require robust data and disclosure standards, ensuring transparency in climate actions and enhancing public and investor trust. As regulatory frameworks tighten, they create a predictable landscape for investment in low-carbon technologies.

### Technological innovation supports rapid take-up of clean technologies

Technological innovation plays a crucial role in accelerating the energy transition. High levels of investment in low-carbon infrastructure – such as renewable energy, smart grids, and electric vehicle charging networks – drive rapid progress. Breakthroughs in renewable energy, energy storage, and carbon capture and storage (CCS) reduce costs and enable widespread adoption.

International collaboration and knowledge-sharing amplify the diffusion of these technologies, ensuring developing nations also benefit from advancements. This creates a virtuous cycle where innovation and deployment reinforce each other, accelerating the transition to a low-carbon future.

### The global economy experiences a transformative shift, supportive of growth

The global economy undergoes a transformative shift as decarbonisation efforts unfold. While the upfront costs of transitioning to a low-carbon economy are significant, they yield substantial long-term benefits. These include accelerated technological innovation, job creation in emerging green industries and a marked reduction in climate-related damage.

By 2050, clean technologies generate 96% of the world's electricity, with renewable sources accounting for 80% of global electricity production. This rapid transition boosts energy security, reduces dependence on fossil fuels, and positions the global economy for sustainable growth.

Developed nations play a pivotal role by providing substantial financial and technological support to developing countries, enabling equitable progress in emission reductions and climate adaptation.

Although physical climate damages are significantly reduced compared to higher-emission scenarios, the costs of adaptation remain substantial. These expenses are driven by the need to reinforce critical infrastructure, protect vulnerable communities, and manage the residual risks that persist even under a below +2°C pathway. However, adaptation costs are considerably lower than in more severe warming scenarios, allowing for a more efficient allocation of resources. This investment not only enhances resilience but also positions the global economy for sustainable, long-term growth by mitigating future climate-related disruptions and fostering stability.

# High emissions scenario

In the **high emissions scenario**, global temperatures rise more than +3°C above pre-industrial levels by 2100, triggering catastrophic impacts on ecosystems, infrastructure and global economies. This trajectory is marked by unchecked emissions growth, weak climate policies and delayed transition to renewable energy, locking the planet into severe and escalating climate risks.

### Emissions remain on an upward trajectory

Global emissions remain on an upward trajectory, only plateauing (at high levels) toward the end of the century. Fossil fuels remain the dominant energy source due to the slow adoption of renewable energy and the absence of robust international climate agreements. Although some regions or sectors implement limited mitigation measures, they are insufficient to counteract the continued rise in emissions, driven by growing energy demands and economic expansion. Consequently, atmospheric $CO_2e$ concentrations continue to increase, pushing global temperatures past critical thresholds and intensifying climate impacts.

### Government failures and fragmented climate action

Collective government action is insufficient to address the worsening climate crisis, with adaptation costs steadily rising. Governments prioritise short-term economic growth over long-term sustainability, delaying meaningful climate policies and weakening international cooperation. Climate regulations are rolled back or poorly enforced, undermining global decarbonisation efforts. Carbon markets stagnate, with low carbon prices offering minimal incentives for emission reductions.

Limited consideration is given to environmental challenges. Instead of proactive intervention, governments and businesses rely on market forces to deliver technological solutions to climate challenges – a strategy that proves ineffective without coordinated global action.

### Economies become increasingly impacted by climate change

The global economy remains oriented toward short-term economic gains, with a "business as usual" approach prevailing among companies and governments, exacerbating climate risks and leaving the world ill-prepared to manage the escalating impacts of climate change.

Rising global temperatures lead to escalating climate impacts, including extreme weather events, sea level rise and biodiversity loss. These impacts inflict significant economic damage, particularly in vulnerable regions, where developing nations bear the brunt of the consequences. Infrastructure is frequently damaged or destroyed, agricultural productivity declines and supply chains are disrupted, driving up costs and reducing economic growth. Forced migration due to climate impacts also adds to social and economic strain, with cross-border movement increasing as regions become less habitable.

Adaptation measures are implemented in some regions, but they remain reactive and insufficient to address the scale of future escalating risks. Investments in mitigation technologies, like renewable energy and carbon capture, lag far behind what is needed, constrained by limited political will and inadequate funding. With limited and fragmented climate action, countries are increasingly vulnerable to systemic economic and environmental shocks.

### The adoption of renewable energy and other clean technologies is limited

The transition to renewable energy slows, hampered by weak climate policies, inadequate investment and the continued reliance on cheaper fossil fuels. While renewable energy's share in global electricity rises modestly (e.g. solar and wind generation increase from 15% in 2024 to 22% by 2050), fossil fuels continue to dominate the energy mix. Zero-carbon electricity generation grows only marginally from 43% and remains below 60% by 2050.

Aging energy grids, unable to accommodate the variability of renewables, require costly upgrades that are often deprioritised, stalling the shift to clean energy. Fossil fuel lobbying and limited international cooperation also hinder the expansion of renewable infrastructure. Similarly, CCS and other clean technologies see slow deployment due to high costs, inadequate funding and technological challenges. As a result, both renewable energy and clean tech remain insufficient to drive meaningful emission reductions, leaving the world increasingly vulnerable to escalating climate risks.

### Climate risks amplify economic and social strain

As the climate crisis deepens, the global economy becomes increasingly volatile. Rising temperatures and more frequent climate disasters (such as storms, droughts, and water shortages) lead to higher food prices, reduced agricultural yields and heightened pollution levels. These factors create a growing drag on economic growth, particularly in developing nations.

Markets become more volatile as the costs of climate adaptation and disaster recovery outpace economic gains. Despite growing public awareness of environmental challenges and the need for urgent action, governments and markets remain slow to respond, exacerbating the risks of systemic environmental shocks and economic inequality.

### Economic growth stalls and then contracts

Global GDP growth slows and eventually begins to contract as the escalating costs of adapting to climate impacts begin to outpace broader technological progress. Developing nations face catastrophic declines in GDP as they struggle to cope with mounting climate-related damages, while wealthier nations experience slower or negative growth due to increased adaptation and recovery costs. Without coordinated global action, the world faces a future of economic stagnation, social unrest, and widening inequality as the impacts of climate change become increasingly unmanageable.

# Economic impacts

This section analyses how key macroeconomic variables – including GDP, investment, industrial production, inflation and interest rates – vary across our climate scenarios.

### Gross domestic product (gdp)

In our **below +2°C scenario**, the most important influences on GDP growth are demographics and the convergence of productivity levels between developing and advanced economies. Based on UN population projections, growth in the global working-age population will slow from around 1% y/y currently, to just 0.2% by 2050. This will act as a significant drag on growth. Given the recent sharp falls in birth rates in many countries, there is further potential downside risk from this perspective.

In addition, although developing economies' levels of productivity and income continue to converge with advanced economies' levels, they do not generate as much growth compared to the preceding 25 years. China's convergence rate has slowed rapidly since the pandemic and, given its structural problems, we do not expect it to re-accelerate. Furthermore, the relatively rapid convergence over the past 25 years has happened in an environment of falling barriers to trade and international investment. These barriers are rising again, meaning that following the same path of growth, through integration into the world economy, will be more difficult for lower income countries.

We also expect some damage to GDP from climate change even though global temperatures are successfully limited in this scenario. Higher temperatures and more frequent extreme weather are likely to reduce global GDP by 2–3% by 2050. This is a much smaller impact than for the central and high emissions scenarios, but nonetheless it is a significant cost when cumulated over time. Note, it is much higher than the estimated costs of decarbonisation.

In addition, in our below +2°C scenario, decarbonisation costs do initially weigh on GDP growth modestly in the early part of the forecast period, reducing global GDP by around 1% relative to the central scenario, until wider adoption brings down the cost of green technologies.

All-in-all, these factors mean that global growth gradually decelerates to around 1% by 2050, significantly below the 2.5– 3% that has been the average over the past ten years. There are upsides to these projections. AI could deliver greater productivity growth and emerging markets could find the right policy mix to continue to grow rapidly. However, there are also downsides – a war could break out between major countries, or birth rates could fall more sharply.

Our **central scenario** has a substantially lower level of global GDP by 2050 than the below +2°C scenario. Growth is marginally stronger in the first five to ten years as a slower pace of decarbonisation in the central scenario means more modest costs. However, from the mid-2030s onwards, the impact of climate change on the world economy grows.

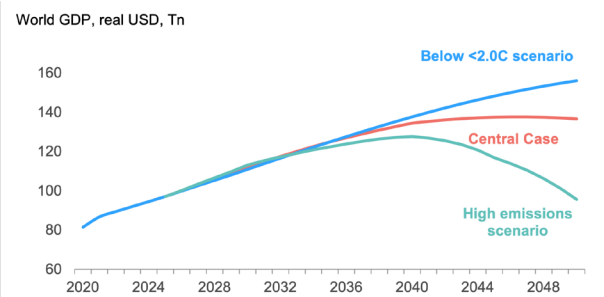
To summarise, based on a meta-analysis of the literature, we believe GDP in our central scenario will be 12–13% lower than in our below +2°C scenario by 2050. This means that global growth in aggregate essentially slows to zero by the end of the 2040s (see chart below). These average impacts vary substantially at a regional level, as explained in the following section.

In our **high emissions scenario**, the impacts are even more severe. World GDP falls in outright terms from the 2040s as a collapse in major ecosystems leads to huge economic dislocation. Countries are forced to devote an increasing share of their resources to climate adaptation, but higher spending on adaptation can only partially ameliorate the impacts of a hotter and more volatile climate. By 2050, GDP is 30% below the central case, and almost 40% lower than the below +2°C scenario.

Higher emissions scenarios lead to substantially lower GDP by 2050

## Industrial production (IP)

(IP) in the **below +2°C scenario** grows slightly




*DATA: CRU Industrial production (IP)*

faster than GDP throughout the forecast horizon. Trends vary by region – some economies such as India and Indonesia see IP rise as a share of GDP, while most advanced economies see it plateau or slightly fall. An important factor that lifts IP globally is heavy spending on the energy transition. We expect investment in the energy transition to boost global IP by around $600 bn per year in real terms, under this scenario.

IP is 13–14% lower in the **central scenario** than in the below +2°C scenario by 2050. The primary driver of this is simply lower GDP. However, the difference in IP between the two scenarios is larger than the difference in GDP. This is because, with a much slower pace of decarbonisation in the central case, there is less of a boost from spending on the energy transition.

This is partly offset by higher adaptation spending. In the central case, governments, businesses and households need to spend more on flood defences, cooling systems and other investment that reduces the impact of extreme weather. However, our assessment is that adaptation spending will be on a much smaller scale than mitigation spending.

In the **high emissions scenario**, IP is drastically lower than the central scenario. The main reason for this is much lower levels of GDP. This is compounded by less equipment-rich spending on the energy transition as efforts to decarbonise stall. There is a limited boost from stronger spending on climate adaptation, but this is not sufficient to outweigh lower mitigation spending and GDP.

## Inflation and interest rates

In **our below +2°C scenario,** we assume that inflation remains anchored to target levels in advanced economies and emerging markets with more credible and stable monetary frameworks. Inflation remains higher in those developing economies with a history of more volatile inflation and weaker institutional frameworks, but it does not trend upward. Interest rates decrease as demographics reduce demand in the global economy.

Inflation is higher in our central scenario as we expect climate change to increase the frequency and severity of supply side disruptions. Although central banks with strong credibility can reduce inflation after shocks, they cannot anticipate these and therefore cannot control inflation perfectly in real time. This means inflation is higher on average, as well as being more volatile.

This increase in inflation will be more pronounced for countries which are more exposed to climate impacts, have higher existing inflation rates, and less credible monetary regimes.

In the **high emissions scenario**, inflation is likely to get out of control even in advanced economies with solid institutional frameworks. Extreme pressures on public finances will lead to fiscal dominance, where monetary policy becomes subordinate to the financing needs of the government. Historically, this has usually led to extremely high inflation, or outright hyper-inflation.

# Impact on key metals markets

Decarbonisation will have major impacts on both metals' demand and supply markets. Metals currently account for just over 10% of global emissions, with steel being by far the largest emitter. Decarbonisation will require significant investment in technology through many value chains. At the same time, metals and critical minerals are vital for the energy transition.

The table below summarises the demand and supply impacts for different metals. For some metals – copper and the so-called 'battery metals' (lithium, nickel and cobalt) – the main effect will be to boost demand, as they have a critical role to play in many of the technologies needed to decarbonise the world economy. In contrast, for the steel industry the main issue is how to decarbonise its own value chain.

Ultimately, this requires a shift away from blast furnaces using metallurgical coal. Greater production using recycled steel can only fill part of this gap, so new processes are needed. At present, Direct Reduction Iron (DRI) using green hydrogen ($H_2$-DRI-EAF) seems to have the most momentum behind it. However, this production route has its own challenges, in particular the availability and cost of high-grade iron ore and green hydrogen. Therefore, a wide range of technologies are likely to be in operation by 2050.

Aluminium is somewhere in between copper and steel, in the sense that decarbonisation will have important impacts on both its demand and supply. A separate supplement scheduled for future publication will expand on the key decarbonisation issues facing each commodity value chain.

**The impact of the energy transition on different metals: Summary table**

| | Impact on demand | Impact on supply |
|---|---|---|
| **Battery metals (Li, Ni, Co)** | Huge increase in demand from EVs and stationary (grid) storage. | Higher power prices will push up costs. The mining sector will face pressure to decarbonise and reduce biodiversity impacts. |
| **Copper** | EVs, renewables, grid investment and electrification will be big demand drivers. | The mining sector will face pressure to decarbonise and reduce biodiversity impacts. Limited downstream impacts. |
| **Aluminium** | EVs, solar and grid investment will help drive demand. | Will need to compete with other sectors for green electricity (H2, home heating, transport, industry). Emissions from anodes need a technological solution. |
| **Iron and steel** | Wind, solar and grid infrastructure requires steel, but volumes are modest, relative to existing end-use sectors such as construction. | Huge shift in technology needed to decarbonise production. More scrap-EAF, but also H2-DRI-EAF or other technology pathways needed. |
| **Rare earth elements** | EVs and wind will be huge demand drivers. | Limited direct impacts, but intersection of green policy and geopolitics will be crucial. |

# Conclusion

Our scenario analysis performs three main functions. Firstly, it helps businesses and other organisations to **understand and prepare** for a range of possible outcomes. Building a scenario is an exercise in 'what if …?' and understanding what needs to happen for a particular scenario to materialise. In this case, what changes in the global energy system are required for climate change to be limited to +2°C? What if we do not transition or decarbonise fast enough – what will the implications be?.

Each scenario consists of a narrative that tells how the scenario unfolds, what is driving change and how this influences outcomes. This is accompanied by projections defining how key variables may change in different states of the world. This lets users of scenarios assess the impact of scenarios on facilities, commodity markets and regions, in a consistent way.

Secondly, our scenarios illustrate the **risks** posed to the world economy and commodity demand by a changing climate. What is more, our bottom-up analysis of commodity value chains – including hard-to-abate sectors like steel – highlights how challenging decarbonisation will be. Businesses need to prepare either for a much harder push from policy and regulation, or for dramatic impacts on the world economy – or both.

At the same time, thirdly, our scenario analysis also brings out the huge **opportunities** that flow from the energy transition. Decarbonisation will require whole new value chains being developed, and new technologies to be rolled out at unprecedented speed. The companies that position themselves to benefit from these trends, while managing the risks, will be those that succeed in the coming decades.

In summary, scenario analysis is a useful tool to help **improve strategic thinking, quantify risks** and **uncover opportunities** across a range of plausible climate pathways. Ultimately, scenario analysis equips leadership with the evidence and foresight needed to make informed decisions that support both competitive advantage and long-term sustainability.

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