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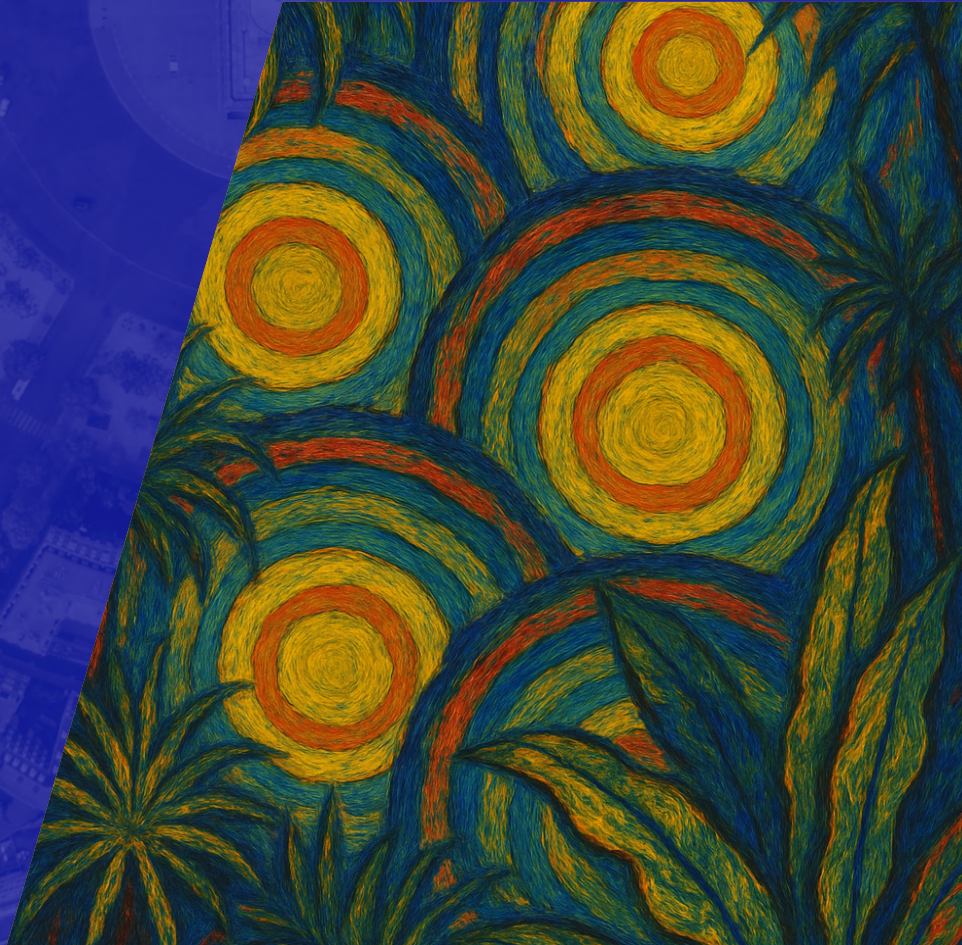
CEPR PRESS

PARIS REPORT 3

# Global action without global governance

Building Coalitions for Climate Transition  
and Nature Restoration

Edited by Jean Pisani-Ferry, Beatrice Weder di Mauro  
and Jeromin Zettelmeyer



# GLOBAL ACTION WITHOUT GLOBAL GOVERNANCE BUILDING COALITIONS FOR CLIMATE TRANSITION AND NATURE RESTORATION

Paris Report 3

In collaboration with Bruegel

**CEPR**

WITH SUPPORT OF CEPR PARIS FOUNDING PARTNERS



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# **GLOBAL ACTION WITHOUT GLOBAL GOVERNANCE BUILDING COALITIONS FOR CLIMATE TRANSITION AND NATURE RESTORATION**

**Paris Report 3**

**In collaboration with Bruegel**

**Edited by**

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Bruegel, PIIE and CEPR

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**CENTRE FOR  
ECONOMIC  
POLICY  
RESEARCH**

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# Foreword

XVI

GLOBAL ACTION WITHOUT GLOBAL GOVERNANCE: BUILDING COALITIONS FOR CLIMATE TRANSITION AND NATURE RESTORATION

CEPR's Paris Reports are annual in-depth studies of topical policy issues concerning Europe, complementing the CEPR's longstanding Geneva Reports on the World Economy. The first Paris Report, *Rebuilding Ukraine: Principles and Policies*, was published in November 2022. The second Paris Report represented the first output from a new joint initiative between CEPR and Bruegel: *Important Topics of Common European Interest (ITCEI)*, focused on Europe's economic security challenges in the face of supply chain vulnerabilities and geopolitical shocks.

*Global Action Without Global Governance: Building Coalitions for Climate Transition and Nature Restoration*, is the second output from the ITCEI initiative. It is a response to a sobering geopolitical reality: that the multilateral order is faltering just as the urgency to address climate change and biodiversity loss reaches a critical juncture. This third volume in the CEPR Paris Report series departs from conventional approaches by proposing a new architecture of international cooperation, one that does not rely on universal consensus, but instead builds momentum through coalitions of willing actors. The report contends that success in climate and nature restoration now hinges on emerging and developing economies, and it offers a pragmatic strategy to align global environmental goals with national economic interests.

Structured around four interlinked pillars (carbon pricing, climate finance, green industrial partnerships, and scalable mechanisms for nature restoration) the volume lays out a coherent, actionable plan for advancing the global commons in an era of political fragmentation. It draws on the strengths of advanced economies, the renewable potential of developing nations, and the growing role of subnational actors to propose variable-geometry coalitions capable of moving the needle where universal frameworks have stalled. The result is not only a set of proposals, but a blueprint for climate and biodiversity action that is as realistic as it is ambitious.

Our thanks go to Anil Shamdasani for his skilled handling of its production. We thank Bruegel and CEPR communications, events, and project teams in organising meetings and workshops that informed the report.

Beatrice Weder di Mauro would like to thank Tokyo College for their hospitality in the period during which she worked on this book.

CEPR, which takes no institutional positions on economic policy matters, is delighted to provide a platform for an exchange of views on this crucially important topic.

Tessa Ogden  
Chief Executive Officer, CEPR  
July 2025

# Introduction: Building coalitions for climate transition and nature restoration

**Jean Pisani-Ferry,<sup>abd</sup> Beatrice Weder di Mauro<sup>cd</sup> and Jeromin Zettelmeyer<sup>ad</sup>**

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## 1 INTRODUCTION

The planet's future depends increasingly on emerging and developing economies. Advanced economies continue to matter because of their higher per-capita emissions, their shares of global trade and finance, and their influence through research, technology and diplomacy; but their share in global greenhouse gas emissions is shrinking. Success in stopping global warming and halting biodiversity loss hinges on whether countries such as India, Indonesia, Brazil and South Africa adopt low-carbon, nature-positive development paths, and if they do so quickly. The same applies to China, which is both the world's top emitter of CO<sub>2</sub> and the country at the forefront of the green industrial revolution.

Geopolitical fragmentation, shifting priorities and a hostile US administration are slowing the transition to a more sustainable economic model in line with the landmark Paris Climate Agreement of 2015. With climate and nature degradation accelerating, governments that understand the importance of climate and nature actions – still in the majority – are faced with hard questions. Recent international discussions on climate change mitigation and the preservation of biodiversity have centred on ambitious targets and the closing of funding gaps. These remain important topics for negotiation but are no longer sufficient. Instead, a broader approach is required to connect mitigation with adaptation and the preservation of nature.

This calls for deeper cooperation among countries with common interests in trade, clean energy and nature. Recognising that this group will for now not include the United States, we propose coalitions of the willing for climate, biodiversity, trade and finance – wherever mutual interests can still align.

The European Union will need to play a special role in the creation of these coalitions. Because of its strong consensus around climate science, an ambitious decarbonisation agenda and a functioning, expanding emissions trading system that has delivered high carbon prices, it has both the credibility and the responsibility to lead, engaging emerging markets and developing economies (EMDEs) and building financing alliances with other advanced countries.

## 2 THE CASE FOR ACTION

In a darkening geopolitical landscape, the pace of technological innovation is a bright spot. Renewable energy and other green technologies have rapidly gained cost competitiveness and scale. Most new renewable power is now cheaper than fossil fuel-based alternatives. The IEA (2024), IRENA (2024), Lazard (2024) and Wood Mackenzie (2024), among others, have shown that the levelised cost of electricity (LCOE) of unsubsidised solar and wind is often lower than that of fossil fuel-based electricity generation, especially when considering new power plant construction.

Solar photovoltaic (PV) costs have plummeted to roughly \$0.04 per kWh, making solar power more than 50% cheaper than generation from fossil fuels or nuclear plants (IRENA, 2024). Even accounting for network and backup costs, this is major progress that is bound to affect the energy pecking order. This dramatic cost decline, alongside improvements in wind turbines and battery technology, means clean technologies offer better economic returns than coal or gas. In dollar terms, investment in renewables now outpaces fossil electricity investment by ten to one, with more investment in solar than in all other power sources combined. Year-on-year global growth in electricity generation from solar PV was double the growth from all fossil fuels combined in 2024.<sup>1</sup> Other green technologies are also scaling quickly. Meanwhile, electric vehicle sales have risen from 3 million units in 2020 to 17 million units in 2024 (IEA, 2025).

But despite these developments, investment in new coal-fired power plants continues, particularly in China, which approved 106 gigawatts of new coal power capacity in 2022 alone – four times the amount approved in 2021.<sup>2</sup> Reasons for this include concerns about supply security, local support for coal and the high upfront cost of investment in renewables that many countries find difficult to finance. Unless retired early, these coal plants will remain in operation for decades, locking in emissions far beyond 2030. Meanwhile, the global vehicle fleet remains overwhelmingly dependent on fossil fuels: in 2024, more than 95% of vehicles in circulation still had internal combustion engines<sup>3</sup>.

Consequently, climate policies and trajectories are far off the path needed to reach emissions targets compatible with the Paris Agreement's objective of limiting global warming to 1.5°C above pre-industrial levels. Continuing with today's policies is projected to lead to about 2.7°C of warming by 2100.<sup>4</sup> Moreover, aggregate projections mask stark differences between advanced and developing economies. Emissions in most advanced economies have already peaked and steady declines have begun. In contrast, emissions in many EMDEs are still rising, driven by economic and population growth and continued heavy reliance on coal, oil and gas.

1 Authors' calculations based on the Ember electricity dashboard (<https://ember-energy.org/data/electricity-data-explorer/?data=generation>).

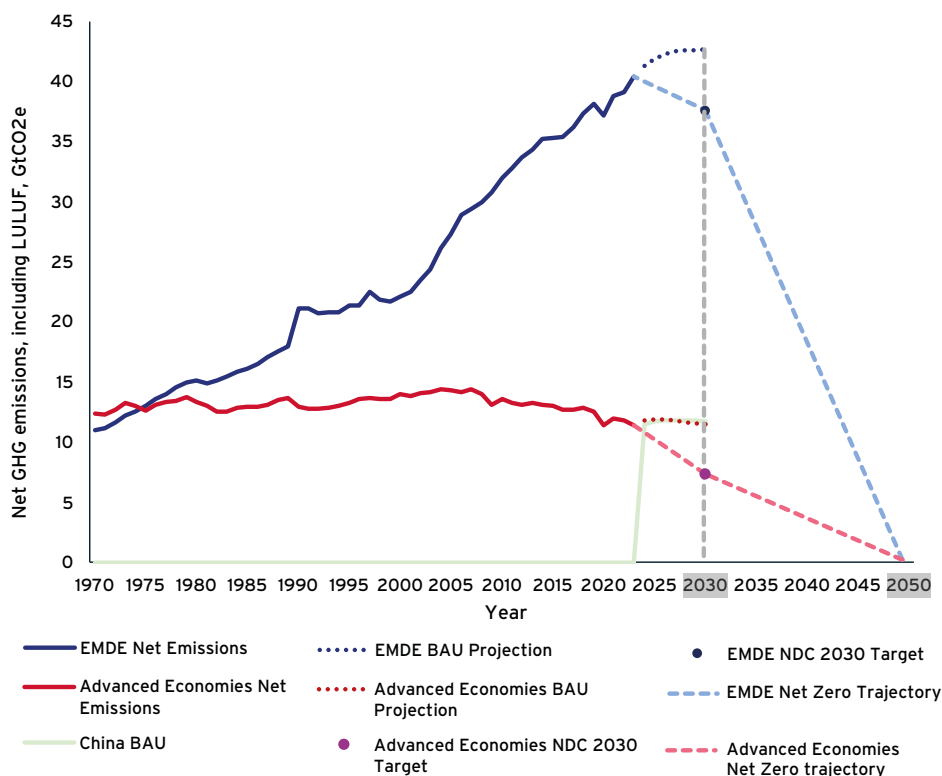
2 See <https://www.reuters.com/world/asia-pacific/chinas-new-coal-plant-approvals-surge-2022-highest-since-2015-research-2023-02-27>

3 Source: <https://ourworldindata.org/electric-car-sales> (updated May 2025).

4 Source: <https://climateactiontracker.org/global/emissions-pathways/>.

As of 2023, EMDEs (including China) accounted for roughly two-thirds of global emissions. Their share is expected to grow further as they contribute the bulk of new emissions. Advanced economies account for a shrinking portion of annual emissions (for example, the European Union and United Kingdom together now contribute only about 8% of global emissions). Reaching global net zero emissions by 2050 requires a sharp break with the current emissions trend in EMDEs (see Figure 1, taken from Chapter 1 in this volume by Grabbe et al.). Limiting global warming to 1.5°C would require an even more radical break, consistent with reaching global net-zero emissions by the mid-to-late 2030s rather than 2050.<sup>5</sup>

**FIGURE 1 HISTORICAL EMISSIONS, 1970-2023, AND REQUIREMENTS FOR REACHING NET ZERO IN 2050**



Note: Several countries, including China and India, have set less ambitious targets. \*EMDEs includes China. The 2050 projection is given for EMDEs as a whole and not separately for China.

Source: Grabbe et al. (2025), based on the IMF Climate Change Dashboard.

<sup>5</sup> According to the Potsdam Institute for Climate Impact Research's "carbon clock", the remaining 1.5°C-consistent carbon budget is just 173 gigatonnes (Gt) of CO<sub>2</sub> (about five times 2023 emissions), while the remaining 2°C-consistent carbon budget is 923 Gt. The cumulative emissions implied by the net zero scenario shown in Figure 1 are about 525 Gt of CO<sub>2</sub>, consistent with a global temperature rise of about 1.7°C - a dangerously high level given the risk of climate tipping points even for a 1.5°C rise (Armstrong McKay et al., 2022).

EMDEs are also custodians of much of the planet's natural capital, so that collective climate outcomes are intertwined with how those countries manage nature and biodiversity. Many of the world's critical carbon sinks and biodiversity hotspots (including tropical forests and wetlands) are located in developing regions across Latin America, Africa and Asia. These ecosystems bolster climate resilience by absorbing CO<sub>2</sub> and providing a buffer against extreme weather. Conversely, their destruction would accelerate climate change and undermine adaptation efforts. Nature-based solutions, such as reforestation and ecosystem restoration, could provide 20% to 30% of the emissions reductions needed to limit warming to 1.5°C.<sup>6</sup> However, continued deforestation or ecosystem collapse (for instance, of the Amazon rainforest) would release vast amounts of carbon and destabilise regional climates. Climate change and biodiversity loss are mutually reinforcing: climate change is now a leading driver of biodiversity loss, and in turn the erosion of biodiversity undermines natural carbon sinks and ecosystem resilience. It follows that preserving nature – alongside cutting emissions – is essential for climate stability and nature sustainability.

The costs of the green transition and of restoring/protecting nature in emerging economies are often disproportionately high relative to their GDPs and fiscal capacities. Our best guess estimates of the investments needed are far above current investment levels in EMDEs (excluding China). In practice, annual clean-energy investment in developing regions would need to more than quadruple from 2022 levels by 2030. This would be unprecedented. It reflects the reality that many EMDE economies are both carbon-intensive (hence requiring more investment to decarbonise) and growing rapidly (hence needing more energy infrastructure overall).

Financing these investments is challenging because of the high cost of capital in EMDEs. Capital for clean energy projects is considerably more expensive in developing markets, reflecting higher macroeconomic risks, regulatory and political uncertainty, and less developed financial systems (see Chapter 10 by Berglof et al., Chapter 2 by Fornaro et al., and Chapter 11 by Sen). For example, in 2021 the real cost of capital for a utility-scale solar PV project was about 3% in Europe and the US, but roughly 7% in India and Mexico, over 9% in Brazil and as high as 10–15% in sub-Saharan African countries (IEA, 2023). This steep disparity in financing costs greatly inflates the levelised cost of renewable energy in emerging economies, often offsetting their natural advantages, such as abundant solar irradiation.

International climate finance is supposed to help bridge this gap, but it remains insufficient. Support has fallen short against lofty pledges. In late 2024, advanced countries agreed in principle (the 'Baku commitment') to provide about \$300 billion per year in climate finance for developing nations, but the flows in 2022 were around \$100 billion. The gaps in nature conservation are equally mind-boggling. To reverse

6 See Chapter 7 in IPCC (2022).

biodiversity decline, the Kunming-Montreal Global Biodiversity Framework (2025) calls for a financing gap of about \$700 billion per year to be closed. Of this, \$500 billion per year should come from phasing out harmful subsidies, reflecting the fact that, at present, nature conservation spending is vastly overshadowed by expenditures that harm nature.

One of the main problems with the widely cited finance gap estimates is that they are rarely accompanied by credible strategies to close them. Instead, these figures are often presented as arguments to mobilise funding, particularly from the private sector or through blended finance mechanisms. However, as the disparity between estimated needs and actual flows increases, the effectiveness of gap estimates as mobilisation tools diminishes. Rather than galvanising action, they risk fostering resignation – or worse, a new form of denial, whereby the evidence from climate science may no longer be questioned but the policies needed to combat climate change will. In wealthier countries, particularly those in temperate climate zones, this can lead to a quiet acceptance of failure and a shift in focus to adaptation, the implicit message being that the battle has been lost.

In addition, global collective action to combat climate change faces several new problems:

- A disjointed approach to address highly connected issues: although the containment of global warming and the preservation of nature are linked in multiple ways, they are mostly tackled separately.
- The fraying of multilateralism: the previous remedy to the shortcomings of a disjointed approach would have been to embrace a more holistic strategy, yet nationalism and geopolitical tensions hamper the search for encompassing solutions.
- A lack of adequate incentives: developing countries (for their mitigation efforts) and advanced countries (for their contributions to the financing of these efforts) both face collective action problems, but incentives are not adequately aligned.

To address these problems, a robust and realistic architecture is needed. In the current geopolitical context, such an architecture must be flexible, recognising that a requirement for agreement by consensus will hold the transition back and will give too much say to those that are dragging their feet. Coalitions of countries that are ready to move more quickly offer the best way forward, and are more likely to align incentives. We propose a redesign based on four pillars:

**Pillar 1:** A tiered carbon pricing coalition with a common carbon border adjustment mechanism (CBAM).

**Pillar 2:** A scaling-up of climate finance, conditional on effective decarbonisation commitments.

**Pillar 3:** Green industrial partnerships between advanced and developing countries.

**Pillar 4:** An effective market architecture for large-scale carbon removal and nature restoration, to complement public funding.

### 3 A FOUR-PILLAR STRATEGY

#### 3.1 Pillar 1: A plurilateral carbon pricing coalition with a common CBAM

The 2015 Paris Agreement achieved near-universal participation, with 196 countries agreeing to commit to climate action. This broad involvement was unprecedented, particularly compared to earlier agreements such as the Kyoto Protocol, in which not all developed nations participated (see Chapter 3 by Guérin and Tubiana). Unlike previous top-down approaches, Paris allowed countries to determine their own climate commitments, making it politically feasible for many countries to join and offer pledges according to their capabilities. EMDEs could present both unconditional and conditional targets, explicitly linking goals to financial support from rich countries. Subsequent climate summits have also introduced systematic transparency measures, requiring regular progress reports on emissions reductions, with peer review and pressure.

Ten years on, the Paris Agreement pledges formulated by countries (their Nationally Determined Contributions, or NDCs) make it possible to assess if they add up to the level of effort required to halt global warming (they do not). However, there is no binding enforcement mechanism to ensure that countries meet their commitments. The Paris Agreement cannot adequately address the free-rider problem associated with emissions: the benefits of emissions reductions are global, but the costs are borne by each country.

The second withdrawal of the United States from the Paris Agreement, in January 2025 at the direction of the re-elected President Trump, was a significant setback. But it is also a strategic opportunity for other nations to strengthen international climate cooperation. The absence of the United States from global climate negotiations could enable the European Union and other major global economies such as China, Brazil and India to agree ambitious and coherent international climate strategies, without needing to accommodate constraints created by US domestic politics and preferences. At the same time, it is important that any agreement should be open to future US participation.

Scaling-up effective climate action requires a stronger link between climate policies and trade.<sup>7</sup> We propose, building on Chapter 4 by Clausen et al., that international collaboration take the form of an open and inclusive ‘climate coalition’. Membership obligations would include:

7 See the G7 Leaders' Statement, 12 December 2022 (<https://www.g7germany.de/resource/blob/997532/2153142/960bf2bf29ddb2253fca0c3bf8f983e7/2022-12-12-g7leadersstatement-data.pdf>).

1. adoption of a tiered carbon pricing mechanism; and
2. adoption of a common carbon border adjustment mechanism (and no carbon border adjustment within the coalition).

The EU decision to introduce a CBAM would be an incentive for countries to join the club of climate-ambitious countries. They would gain CBAM exemption, along with possible additional incentives involving technology transfer, climate finance, technical assistance, and clean energy trade liberalisation. Club members would commit to enforce domestic carbon pricing through taxation or equivalent emissions trading systems. They would also adopt CBAMs that impose tariffs equivalent to their domestic carbon prices on imports from non-member nations. This would reduce carbon leakage and maintain competitive fairness.

Importantly, Clausen et al. propose that participation be structured through a tiered carbon pricing system, such as that proposed by the International Monetary Fund (Parry et al., 2021). For example, lower-income countries could implement lower carbon price floors (e.g., €25 per tonne); middle-income countries would be requested to adopt a higher, but still moderate level (e.g., €50 per tonne); and higher-income economies would have higher rates (at least €75 per tonne), with prices adjusted regularly for inflation. Other variations, including differentiation between lower- and upper-middle-income countries, could also be considered.

This differentiated approach aligns with the principle of common but differentiated responsibilities, a cornerstone of previous global climate agreements, and addresses equity concerns by mitigating potential economic impacts on developing nations. The differentiated schedule should serve as a transitional measure, with carbon tax rates increasing as countries achieve higher levels of income. This expectation of carbon price convergence should reduce incentives for carbon-intensive industries to relocate to jurisdictions with lower carbon prices. Both the levels of the tiers and the pace of convergence would be subject to negotiation (see Chapter 4).

The coalition would initially focus on the carbon-intensive goods included in the EU CBAM: aluminium, iron and steel, cement, fertilisers and hydrogen production. These industries comprise a significant share of global carbon emissions (about 20%), including both direct emissions and the emissions from the electricity used in their production. But the CBAM could be enlarged if similar measures are adopted by other countries, for example in East Asia, and be broadened if other goods end up being added to the intermediate products of the initial list.

The size and economic value of the market created by the club will determine the incentives to join. The economic value would determine the club's ability to internalise the climate benefits of collective mitigation efforts.

This proposed climate club would complement the United Nations Framework Convention on Climate Change Conference of the Parties (COP) process by deepening collaboration among coalition members – primarily because it relies on reciprocity and meaningful incentives rather than voluntary commitments and peer pressure. Countries would gain economic benefits from participation and the reciprocal structure would incentivise sustained participation and climate action, while addressing carbon leakage and competitiveness concerns.

A viable coalition should quickly expand from the European Union and its main suppliers to other large countries, including China, Korea, Japan, India, South Africa and Brazil. These countries are, of course, at very different stages of development, and their respective incentives will need to be calibrated carefully. In addition to a tiered schedule for carbon pricing, the design should include commitments to technology transfer and financial support for green transitions in lower-income countries. In light of concerns about industrial overcapacity in sectors such as steel, it may also require an agreement to limit or eliminate subsidies. The European Union would need to play a leading role in establishing this framework.

### **3.2 Pillar 2: Scaled-up climate finance conditional on effective decarbonisation commitments**

The current commitments of advanced countries to finance EMDE decarbonisation are insufficient and are not matched by developing country commitments to decarbonise. Therefore, the implicit contract between North and South can (and in many instances does) result in an unproductive exchange of false promises: advanced countries pretend they will finance decarbonisation in the South, while developing countries pretend that they will decarbonise.

A way out of this conundrum would be to form ‘climate finance coalitions’ involving subsets of advanced countries willing to fund decarbonisation in the South and subsets of developing countries willing to decarbonise their economies if given access to funding on reasonable terms (see Chapter 5 by Bolton and Kleinnijenhuis). This mutual commitment would be in the self-interest of all participating countries: all would gain from the avoidance of physical, health and economic damage thanks to lower emissions in EMDEs, while economic benefits would be roughly in proportion to countries’ GDP. As a result, fiscal support for the decarbonisation of EMDEs (except China) would be in the economic interest of advanced countries and China, even if the EMDEs do not contribute (Chapter 5).

The cost of funding developing country decarbonisation as a share of the GDP of the financier coalition would depend on the size of that coalition. A coalition of all advanced countries and China would pay less than 0.2% of GDP annually for EMDE power-sector decarbonisation consistent with the Paris 1.5°C objective. For a funding coalition that

excludes the United States but includes China, the European Union, Canada, Japan, South Korea and some additional smaller industrial partners, the fiscal burden would be about 0.2% of GDP. If China is also excluded from the financier coalition, the cost would rise to 0.3% of GDP/year.

The greater the economic damage from climate change, the smaller the critical mass of participants would need to be for coalition financing to be profitable. But even if global economic damage (the social cost of carbon) were relatively low (\$190/tCO<sub>2</sub>, as assumed by Rennert et al., 2022), a financier coalition consisting of the European Union and advanced countries except the United States would benefit economically from financing the decarbonisation of most of the largest developing country power-sector emitters. If the United States or China were to join, the coalition would find it in its interest to finance the decarbonisation of almost all developing country emitters. If the assumed damages are significantly higher, as argued by Bilal and Känzig (2025), large entities including the European Union, China (and the United States) would find it profitable to embark on decarbonisation support alone, even if not joined by other partners.

Under the Paris Agreement, all signatories must offer new NDCs at COP30 in Brazil in November 2025. With the next versions not due until 2030, this set of NDCs represents the last chance to put emissions on a net-zero consistent path. The European Union and its climate finance coalition partners should offer conditional fiscal support to all developing countries (except China and oil and gas producers) that are willing to commit to net-zero-consistent decarbonisation of their power sectors. While only accounting for about 40% of developing countries' emissions, power sector decarbonisation is a necessary step for the decarbonisation of industry and transport.

### **3.3 Pillar 3: Green industrial partnerships between the European Union and developing countries**

Europe currently imports most of its oil and gas at relatively high cost. The continent's transition to clean energy will end its dependency on imported fossil fuels, but not its relative energy scarcity (see Chapter 6 by McWilliams et al.). Europe is not well-endowed in green energy. Limited land availability and a relatively poor solar potential (except in Southern Europe) imply that the cost of producing electricity will be higher than in countries on the other side of the Mediterranean, in the Middle East or in Africa. Nuclear power can help, but not to the point of eliminating Europe's structural cost disadvantage, as nuclear is relatively expensive compared to renewables once the possibility of electricity storage is factored in.

As a result, Europe will remain an energy importer in the medium and possibly long term. However, transporting electricity is much more costly than transporting fossil fuels, even taking into account the possibility of producing hydrogen and transporting it by sea or through pipelines. In contrast, energy-intensive intermediate products in the value chains of the chemical and steel industries, such as ammonia, fertilisers, methanol and reduced iron, can be easily and cost-effectively transported by sea.

For this reason, the green transition is bound to transform the international division of labour along value chains. Developing country exporters of primary products such as iron ore are likely to move down the value chain and export processed products, such as direct reduced iron, instead of raw commodities. Consequently, some upstream segments of European energy-intensive industries (EIIs) would move South. This restructuring of global value chains would be economically efficient and would help the industrialisation of the South. To the extent that energy-intensive intermediate inputs, such as ammonia or direct reduced iron, are produced with green electricity or green hydrogen, it would also lead to significant greenhouse gases emission reductions.

This leaves two important questions unanswered:

1. how to ensure that the migration of energy-intensive production supports Europe's own green industrialisation goals and, more broadly, its efforts to improve its competitiveness and its economic security; and
2. how to ensure that it results in global emissions reductions, rather than simply carbon leakage from the European Union to the Global South.

McWilliams et al. seek to answer both questions. On the first, they argue that the direct value added and employment loss of the relocation of energy-intensive intermediate products to the South would be modest. In Germany, EIIs account for most industrial energy demand but only 5% of manufacturing wages and 6% of the value added. The upstream segments of those industries represent a fraction of those numbers. At the same time, relocating these production stages should not only boost the competitiveness of downstream EII segments but also industrial competitiveness more broadly, by reducing energy costs. Substituting domestic production of ammonia, methanol and reduced iron by imports could reduce EU electricity demand by around one-quarter of today's green electricity production in the European Union, and around one-tenth of 2050 projected demand (see Chapter 6). The ensuing impact on EU energy prices would benefit industrial consumers, households and the public purse.

The policy implications are two-fold.

First, while subsidies to modernise and protect European heavy industry can be justified both by the green transition and by the need to retain potentially competitive industry in a context of possible Chinese overcapacity, public money should both be conditional on abatement efforts *and* go to less energy-intensive downstream industries, rather than highly energy-intensive intermediate products. This requires a revamping of the EU Clean Industrial Deal, which does not presently discriminate between production stages that should remain in the European Union in the long term and those that need not.

Second, EU industrial policy must be linked to trade, investment and climate policies that embed low-cost energy intensive production in developing countries into EU value chains. The two pillars of EU climate policy discussed above – an EU-led carbon pricing and CBAM coalition, and an EU-led coalition to fund decarbonisation of power sectors in developing countries – are critical in this regard. In addition, Clean Trade and Investment Partnerships, as announced by the European Commission (Jütten, 2025), would need to be set up to both improve market access to the European Union and transfer technology to those developing countries that have the potential to be reliable suppliers of green energy-intensive intermediate products.

Conceptually, the same reasoning could apply to the decarbonisation of other advanced countries. We have presented it for Europe because it is where the policy question arises.

### **3.4 Pillar 4: Effective markets for carbon removal and nature restoration**

It is almost certain that the world will overshoot climate targets. This makes investment in negative emissions essential. Limiting global warming to below 1.5°C does not rely only on the containment of emissions, but also on large-scale deployment of carbon dioxide removal (CDR) technologies of all kinds. Some models project gross CDR volumes of 10 to 20 GtCO<sub>2</sub> per year by the second half of the twenty-first century, equivalent to one-quarter to one-half of today's global emissions (Hoegh-Guldberg et al., 2018).

Negative emissions can be achieved through natural sequestration, which relies on photosynthesis and ecosystem processes (e.g., afforestation, soil carbon, carbon stored in coastal and marine ecosystems), and technological solutions that extract CO<sub>2</sub> from the atmosphere, such as direct air capture and storage (DACs), which does not yet exist at scale.

This pillar proposes two market innovations:

- *A market mechanism for negative emissions:* integrating clean-up certificates into compliance markets (starting with the EU emissions trading system, or EU ETS) for carbon removals that are reliably permanent.

- *Credible markets for long-term nature-based carbon capture* that also value the broader ecosystem services and co-benefits of nature restoration – not just the carbon.

The goal is to prepare for a future in which net-negative emissions will be necessary in the second half of the century, to compensate for temperature overshoot and restore a safer climate trajectory.

*A market mechanism for negative emissions: Clean-up certificates*

Following Chapter 7 by Edenhofer et al., we propose a new market-based instrument in the form of clean-up certificates, designed to embed CDR into the EU ETS and make the financing of net-negative emissions feasible at scale. The certificates would offer firms a legal right to emit beyond their allowances today, in exchange for an obligation to remove the equivalent amount of CO<sub>2</sub> from the atmosphere in the future. This creates a form of carbon debt, explicitly linked to future removals.

The EU ETS is approaching a structural turning point. Under current rules, the last allowances for energy and industrial sectors will be auctioned around 2039. Yet some residual emissions – particularly in hard-to-abate sectors such as cement – will remain too costly or infeasible to eliminate. Without a mechanism to offset these emissions, carbon prices could spike in the 2040s, undermining the predictability and effectiveness of the EU ETS. Moreover, firms are already making forward-looking investment decisions and are banking certificates. Introducing clean-up certificates now would enable regulated entities to anticipate future compliance costs, while generating demand and finance for removals today.

The institutional redesign would involve two steps:

1. Issuance of clean-up certificates: these certificates would authorise emissions today but create a carbon debt obligation to remove the equivalent CO<sub>2</sub> in the future.
2. Creation of a European Carbon Central Bank (ECCB), which would oversee the issuance, verification and enforcement of carbon debt contracts. It would act as a regulatory and financial anchor, ensuring transparency, risk management and intertemporal consistency in carbon markets.

Clean-up certificates introduce intertemporal flexibility into emissions trading – analogous to allowing not just banking but also borrowing. Firms can emit now and remove later if they expect future innovations to lower CDR costs. However, if they are pessimistic about future CDR potential, they will avoid incurring carbon debt and prefer immediate abatement.

Time-inconsistency is obviously a major concern. Without safeguards, firms might bet on an excessively high pace of technological progress, become overindebted and end up defaulting on their carbon debt. To prevent such outcomes, Edenhofer et al. propose to grant the European Commission the option of intervening in the market by limiting the amount of clean-up certificates. In addition, reducing the issuance of conventional allowances would increase overall ambition levels as a result of the overall cost reductions from introducing clean-up certificates. To insure against corporate bankruptcy, Edenhofer et al. propose that firms issuing carbon debt post collateral in the form of security deposits at the ECCB. If the firm delivers the expected certified removals, the deposit is released. If it defaults, the ECCB retains the funds and uses them to procure equivalent removals elsewhere.

The EU ETS should thus evolve from a pure mitigation instrument into a tool that manages the entire carbon cycle. Over the longer run, negative emissions from nature-based removals could be integrated, potentially as a separate category of clean-up certificate. The potential for such removals is particularly high in EMDEs and in low-income countries, which also host significant biodiversity. However, two conditions must be met: nature-based removals must be additional and permanent. Achieving this requires a fundamental redesign of nature markets, which we address next.

#### *A market for natural provision of negative emissions and nature restoration*

In Chapter 8, Cantillon et al. propose a novel design for nature markets to scale up carbon removals and nature restoration in the Global South. The aim would be to overcome the high transaction costs, low credibility and short-termism that characterise the current voluntary carbon markets. The proposed mechanism would address these design flaws through four innovations:

1. *Jurisdictional scale*: projects would be defined at regional or provincial level rather than small-scale private projects. This scale would reduce leakage, improve monitoring and enhance additionality by aligning with regulatory boundaries. Jurisdictions would compete to attract capital.
2. *Equity-based instruments*: instead of issuing credits, jurisdictions would sell shares in a portfolio of nature-based projects. These shares would entitle holders to receive ‘dividends’ in the form of measured carbon and biodiversity benefits (e.g., a quantity of avoided CO<sub>2</sub>, increase in biodiversity). Dividends would be released prudently over time, with buffers to account for ecological risk. This would allow for permanent claims without assuming permanence in ecological systems.
3. *Primary market as a crowdfunding mechanism*: jurisdictions would list projects with detailed descriptions and minimum funding thresholds. Investors would allocate capital across proposals. Prices would form endogenously, with projects that attract excess demand seeing rising share prices, while underfunded projects would be delisted. This competitive mechanism would incentivise jurisdictions to improve project quality and additionality.

4. *Public market governance*: to ensure integrity and reduce fragmentation, the market infrastructure – project vetting, registry management – would be publicly governed. This structure should reduce certification costs and resolve conflicts of interest inherent in today’s privately run systems.

The proposed share-based model would address the main shortcomings of credit markets by realigning incentives and embedding long-term commitment. Unlike credit buyers, shareholders would internalise ecological risk, fostering better stewardship and accounting for the impermanence of natural systems. Jurisdictional project scope and competitive pricing would enhance additionality and minimise leakage. By pricing a bundle of project attributes, the model would generate implicit values for biodiversity alongside carbon. Centralised governance and larger project scale would reduce transaction costs, while the secondary market would ensure liquidity. Overall, the approach should shift the market from transactional offsetting to long-term ecological investment.

To scale up, the market would require reliable demand. Rather than relying solely on offsets, a boost to demand could come from mandating institutional investors to align the carbon footprints of their portfolios with the Paris-aligned trajectories (and to do the same with their biodiversity footprints when such standards are established) and authorise them to use nature shares (on top of any other asset reshuffling) to meet this goal. A major advantage of acting at the level of funds, rather than the underlying companies, is that it would not release these companies from any existing or upcoming obligations to decarbonise and reduce their biodiversity impacts.

While the model is well suited for provision projects, conservation is harder to finance because it delivers no flow of carbon and no added biodiversity dividends. The benefits of conservation are in the preservation of stocks of carbon and biodiversity. Cantillon et al. discuss different ways to address this: (1) conservation projects could be integrated into the mechanism, which would facilitate private funding but complicate the design; or (2) it would require a separate funding mechanism, as proposed for the Amazon (see Box 1). In addition, nature-harming subsidies should be eliminated.

### BOX 1 REFORESTATION AND CONSERVATION OF THE AMAZON

The Amazon rainforest is crucial for both capturing carbon and preserving biodiversity. In Chapter 9, Assunção and Scheinkman explore two complementary approaches to finance tropical forest protection in the Amazon: (1) reforestation of previously deforested areas, and (2) conservation of standing forests.

Reforestation - especially through natural regeneration - is shown to be a low-cost and high-impact carbon-removal strategy. In the Brazilian Amazon, approximately 50 million hectares of currently deforested land could capture up to 23 gigatonnes (Gt) of CO<sub>2</sub> over the next three decades. Assuming international payments of \$25/tonne of CO<sub>2</sub>, this reforestation could generate \$572 billion in gross transfers. After adjusting for land-use change costs, lost cattle production and discounting, the net benefit to Brazil is estimated at \$282 billion in present value over 30 years, while delivering 18 Gt in net carbon capture and avoiding 16 Gt of currently foreseen emissions.

This reforestation strategy would be notably cost-efficient: the effective cost per tonne of carbon is just \$13.25, significantly lower than most engineered carbon capture and storage (CCS) technologies currently supported in high-income countries. This reflects the low agricultural productivity (mainly extensive cattle ranching) of much of the deforested land in the Amazon. The policy simulation assumes that payments are tied to net carbon capture, meaning countries would be rewarded only for increasing carbon stocks (e.g., through reforestation) rather than for maintaining existing ones.

In contrast to reforestation, conserving standing forests focuses on preventing future emissions and biodiversity loss. Tropical Forest Forever Facility (TFFF), a Brazilian initiative, proposes annual payments of \$4 per hectare of standing forest, but only for countries with annual deforestation rates below 0.5%. Penalties apply for any new deforestation. The TFFF is designed to reward countries such as Guyana, Suriname and French Guiana, which have high forest cover but limited restoration potential and where deforestation rates are low. Because these countries have little scope for additional net carbon capture, TFFF offers a way to include them in results-based finance by compensating them for protecting high-integrity forests.

Simulated payments under TFFF vary across countries. For example, in a 'zero-deforestation' scenario, Brazil would receive \$28.7 billion via TFFF, compared to \$282 billion from reforestation payments. Guyana and Suriname, with minimal deforestation, would benefit primarily from TFFF, and Colombia and Peru would receive intermediate levels from both mechanisms.

## 4 ROBUST GOVERNANCE

A common thread throughout this chapter is the need to define templates for new, variable-geometry patterns of collective action that will offer alternatives to the severely damaged post-war order and help tackle global commons without resorting to traditional global governance solutions.

For eight decades, the management of global commons has relied on a more-or-less stable template of almost all countries signing up to multilateral treaties, the implementation of which rested on global institutions. For example, international trade was governed by the multilateral General Agreement on Tariffs Trade (GATT) rules, guided by the 166-member World Trade Organisation. Similarly, rules for international capital flows and exchange rate policies were enshrined in the Articles of Agreement of the IMF (191 members), which is also in charge of enforcing them. The same has applied to many other fields, including climate action (195 signatories) and the protection of biodiversity (also 195 signatories).

Those agreements and institutions remain in place, but new patterns of international cooperation have developed:

- Participation in global governance arrangements increasingly departs from the principle that sovereign states have exclusive control over their territory and their citizens and, accordingly, no right to interfere in another sovereign state's affairs, except through international agreements, while private and subnational actors can only intervene in the affairs of others through their national governments. However, the Paris Agreement relies to a great extent on non-state actors such as subnational entities (regions and cities) (see Chapter 3 by Guérin and Tubiana). Many subnational governments have adopted targets and implemented policies that exceed the national ambition. Moreover, civil society, business associations and major private corporations all play a role in the climate governance process.
- Beyond the climate field, ways have been found to ensure the effectiveness of cooperation without relying on mandatory global rules. For example, international cooperation on banking regulation takes place within the framework of the Basel Committee on Banking Supervision, but standards set by this committee are not legally binding on financial institutions or national supervisors. Each country remains free to legislate on financial safety matters, though knowing that the Basel Committee regularly assesses national regulatory frameworks and publishes its findings. This mechanism has so far proved effective in ensuring global financial oversight and improving financial stability.
- Specialised public agencies, such as central banks and regulatory authorities, have developed new forms of cooperation that do not directly involve national governments but rest on the similarity of the mandates of institutions to put in place effective arrangements. A particularly telling example is that of competition authorities, which have found a tacit understanding on their respective scope of extraterritoriality and have accordingly developed new modes of cooperation.<sup>8</sup>

8 For a recent review of global governance arrangements, see Papaconstantinou and Pisani-Ferry (2024).

Patterns of effective international cooperation have therefore become much more diverse, and further innovations can be proposed. Examples include the suggestion by Guérin and Tubiana to give formal status to the involvement of subnational actors by involving them in periodic climate change mitigation assessments; the proposal by Cantillon et al. in Chapter 8 that subnational jurisdictions issue shares that depend for their value on nature preservation performance in their territory; and the plan by Edenhofer et al. in Chapter 7 to entrust a carbon central bank with the mandate of overseeing the market for carbon removals.

Since President Trump took office on 20 January 2025, however, his administration has repeatedly expressed hostility towards the prevailing global governance regime, even going so far as to call it “*a weapon being used against us*”.<sup>9</sup> The United States has withdrawn from the World Health Organisation and the Paris Agreement and is actively undermining other multilateral institutions by flouting their principles – in particular, the WTO. The US administration is also pushing for a reversal of what it describes as a “mission creep” of the Bretton Woods institutions into fields such as climate action, for which the administration claims they have no mandate.<sup>10</sup>

In the context of accelerating deterioration of climate and nature, waiting until the United States resumes its participation in global governance arrangements would imply accepting irreversible damage, and likely catastrophe. Against this backdrop, there is growing interest in new forms of international cooperation, such as coalitions of the willing (Blanchard and Pisani-Ferry, 2025), which seek to preserve cooperation among countries that want to safeguard global commons. Such coalitions are also necessary to develop new collective action schemes among subsets of players.

Making coalitions of the willing feasible and effective requires two distinct, but related, problems to be solved. The first is how to address the free-riding problem inherent to action in fields such as climate and biodiversity, where the rationale for cooperation is to ensure proper governance of the commons. The second is how to prevent leakage resulting from the transfer of footloose industries and activities to jurisdictions with less stringent regulatory or taxation frameworks (which would compound the free-rider problem).

The solution to these problems is partly political, but it also rests partly on the design of the coalition. To get a coalition off the ground requires cooperation by a critical mass of countries that have internal governance mechanisms (such as members of the European Union) or are sufficiently politically aligned and economically integrated to punish free-riding. Once critical mass has been achieved, coalitions must minimise leakage by creating incentives for other countries to join.

9 See [https://www.foreign.senate.gov/imo/media/doc/6df93f4b-a83c-89ac-0fac-9b586715afd8/011525\\_Rubio\\_Testimony.pdf](https://www.foreign.senate.gov/imo/media/doc/6df93f4b-a83c-89ac-0fac-9b586715afd8/011525_Rubio_Testimony.pdf)

10 See <https://home.treasury.gov/news/press-releases/sb0094>

The four pillars of climate action detailed in Section 3 imply a ‘variable geometry’ of intersecting coalitions within the universal membership of the UNFCCC and the UN Convention on Biodiversity. From broadest to narrowest, they are as follows:

1. The potentially widest is the climate coalition corresponding to Pillar 1 of the previous section, members of which would adopt carbon pricing differentiated by the level of development and establish a common CBAM of the type being implemented by the European Union (see Chapter 4). Membership should include all countries that have adopted or consider adopting carbon pricing, including China.
2. Next comes a climate finance alliance of advanced industrial countries, plus China, to promote the decarbonisation of the power sectors of as many developing countries as possible (Pillar 2). This coalition could be linked to the architecture of the Paris Agreement by offering sufficient financial support to fund the phase-in of a renewable energy pipeline to all countries that are willing to commit to (1) net-zero-consistent power sector transformation in their 2025 conditional NDCs; (2) milestones for the phase out of fossil-fuel power sources; and (3) a governance structure to identify and monitor renewables projects and the early closing of fossil-fuel power assets.
3. Green industrial partnerships (Pillar 3) would at a minimum require participation by the European Union and a set of developing trade partners endowed with large renewable energy potential. But this coalition should welcome the entry of additional advanced energy importers of steel, chemical and other energy-intensive industries, such as Japan, South Korea, and the United Kingdom, and their main developing trade partners. The partnership should be open to both advanced and developing countries, and could significantly overlap with other coalitions. But there will be differences, at least initially. While it is essential that China belongs to the plurilateral CBAM (point 1 above and Chapter 4), and while it is desirable that it belongs to the climate finance coalition, climate finance could go ahead without it. More importantly, adopting a carbon price should not be a condition for advanced country financial support for power sector decarbonisation, but it would be a condition for membership of the plurilateral CBAM.
4. Creating nature finance at scale will require a coalition of countries that are custodians of the world’s most biodiverse ecosystems (Pillar 4). Together, they would participate in a credible mechanism to support large-scale nature restoration and carbon removal by offering nature shares. To succeed, the issuance of these shares should be matched by stronger demand for them – ideally led by a group of advanced countries. The European Union could play a pivotal role by fostering the decarbonisation of investment portfolios.

These four coalitions do not just intersect; they also interact and are mutually reinforcing. This is particularly true for the first three pillars:

- Membership of the plurilateral CBAM/carbon price coalition (Pillar 1) would create a price-based incentive to decarbonise the power sector that reduces the need for fiscal subsidies, thereby lowering the fiscal burden shouldered by the members of the financier coalition in supporting decarbonisation in the Global South (Pillar 2).
- Financial support for power sector decarbonisation (Pillar 2) and trade and investment partnerships between EMDEs and the European Union (Pillar 3) could make membership of the CBAM/carbon price coalition (Pillar 1) more attractive for EMDEs.
- The decarbonisation of EMDE power sectors, envisaged in Pillar 2, is a pre-condition for the outsourcing of highly energy-intensive production stages to EMDEs with abundant renewables endowments, as envisaged in Pillar 3.

Because they will be mutually reinforcing, these coalitions should be initiated simultaneously and without delay. In this, the EU has a major role to play: because it will likely be part of all coalitions, it should outline a plan, propose a comprehensive agreement, seek alliances and work out the conditions for its international partners to take part. As the driving force of the Paris Agreement and a key sponsor of the Kunming-Montreal Global Biodiversity Framework, the European Union has the legitimacy and the resources to promote such an initiative.

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# Climate change mitigation and the preservation of nature: Towards a joined-up agenda

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Until recently, the focus of attention of policymakers and informed opinion was on climate change mitigation. Despite its vital importance, the preservation of nature and biodiversity was attracting less attention. Gradually, however, the importance of the latter has become increasingly recognised, especially following the release of the *Dasgupta Review* (Dasgupta, 2021).

The aim of this chapter is to take stock of recent developments regarding both climate change mitigation and the preservation of nature, to discuss their interrelation, and to assess the effectiveness of policies in place.

We first discuss in Section 1 progress and setbacks in mitigating climate change. Our two main takeaways are, first, that green technologies are increasingly competitive and are on the verge of supplanting brown technologies as far as efficiency is concerned; and second, that although complete policy reversals can happen in advanced countries – as illustrated by the stance of the Trump administration – the future of climate mostly depends on whether emerging countries will continue to rely on fossil fuels or embark on ambitious decarbonisation programmes.

The pace of progress in green technologies in the last decade has been astonishing. According to the International Energy Agency (IEA, 2024), the global price of solar panels fell from US\$0.74 million per MW in 2015 to \$0.18 in 2023, while the price of battery storage was reduced from \$1.57 to \$1.02 million per MW. Even though the fall in prices has been less pronounced for wind turbines, there has been progress there too. Assuming the price of fossil fuels remains in the vicinity of its current level, there is by now a clear prospect of the cost of producing and storing renewable energy falling below the price of producing it with fossil fuels in the coming years. This major shift in relative costs is bound to trigger a global industrial revolution.

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Quantitatively, however, fossil fuels still accounted for 80% of world energy demand in 2023 and global emissions of greenhouse gases (GHGs) keep on rising (IEA, 2024). This is mostly due to emerging and developing countries, whose emissions account for nearly four-fifths of the world total. China, the world's number one emitter, may be nearing peak emissions and it may well surprise with the pace of the decline in its emissions. This is not the case for large emerging countries like India, Indonesia, South Africa, and Brazil, however. These economies both have massive investment needs and face a high cost of capital. Moreover, despite the commitments entered into in Baku at the end of 2024, the scale of climate finance falls well short of providing incentives to reverse fast emission growth in these emerging economies.

In Section 2, we turn to a review of the threats to nature preservation. There are many similarities between climate change and the dilapidation of biodiversity, starting with the magnitude of the challenge they represent, the existence of tipping points beyond which irreversibility sets in, and the corresponding urgency of remedial action. Both also have a strong North/South dimension, especially as the vast majority of biodiversity hotspots are located in the South. But there are also significant differences.

First, the preservation of climate is a global public good with limited or no local benefits from emission reductions (although with variations across countries in the impact of the rise in global temperature), while the benefits of preserving biodiversity accrue to local populations as well as globally (for example, by providing global carbon sinks or offering wide genetic variety that could benefit future medication, global health services, and others).<sup>2</sup> In other words, biodiversity involves strong cross-border externalities, but alongside its global public good dimensions it has the properties of a local public good. Consequentially, the prevention of catastrophic changes in climate and biodiversity involves different mechanisms and policy action must rely on different instruments.

In particular, biodiversity protection should a priori be easier to implement because of the local characters of some of its benefits. As emphasised by Oström (2000), solutions for local collective action have frequently been found and implemented successfully. Put differently, local tragedies of the commons (Hardin, 1968) have often been solved, while there are only few examples of successful cooperation solving a global one.<sup>3</sup> Solving the biodiversity challenge is therefore in principle easier, but the global nature of externalities involved suggests that local incentives and local sources of finance are often insufficient to invest in biodiversity protection. A specific example is the protection of the Amazon rainforest: there is a clear local benefit thereof, but the services the rainforest provides are not only local but also global.

2 Significant local benefits can take place when heavy emitting power plants are located in the vicinity of major cities, as it is the case for Beijing.

3 A counterexample is the success of the 1987 Montreal Protocol on eliminating substances that deplete the ozone layer. This was due to the combination of a small number of players and the availability of low-cost alternatives to chlorofluorocarbons.

Climate change mitigation and the preservation of nature also differ with regards to the objectives societies have set themselves and the magnitude of required action. Because most GHGs have a very long lifespan, the mere stabilisation of global temperature necessitates that those net emissions be brought to zero within a few decades. The aims of collective action to preserve nature are in essence more diverse (see Table 1).

Economic dimensions are another source of differences. The value of climate change mitigation can be summarised conceptually by a single variable – the social cost of carbon (or, alternatively, the shadow price of carbon associated with a global emissions reduction objective) – whilst the social value of preserving nature varies considerably from one point on the globe to another, depending on the nature of the resource that is being protected.

Despite these differences, there is value in analysing jointly issues raised by climate change and the deterioration of nature, as we do in Section 3. Both amount to a decline in the natural capital inherited by future generations, with wide-ranging economic, social, and societal consequences. And while action for climate and action for biodiversity are sometimes in competition, they mostly go hand in hand.

Cooperative responses to these challenges at global level, such as those promoted by the Paris Agreement on mitigating climate change and the Kunming-Montreal framework on preserving biodiversity, are obviously superior solutions. Even in the absence of global cooperation, however, countries in the North have a vested interest in supporting action in the South. Section 4 is devoted to discussing if and when ‘coalitions of the willing’ are able to substitute for the lack of global collective action. It turns out that the magnitude of global externalities is such that a subset of willing countries of the North is often sufficient for such coalitions to be effective, provided agreement can be found on the sharing of the burden.

## **1 CLIMATE CHANGE MITIGATION: WHERE DO WE STAND?**

### **1.1 The world is not on the path to reaching net zero by 2050**

Since the Industrial Revolution, the concentration of GHG emissions in the atmosphere has constantly increased due to the combustion of fossil fuels, leading to a global warming of 1.3–1.4°C today.<sup>4</sup> Available projections indicate that the prolongation of policies in place will lead to a rise in global temperature of at least 2.4°C by the end of the century (IEA, 2024). Such an increase in the global temperature would have catastrophic consequences for living conditions, public health, and the economy. Recent research has sharply re-evaluated the social cost of climate change, implying that even a fraction of a degree will have severe economic consequences (Kotz et al., 2024; Bilal and Känzig, 2024).

4 See, for example, <https://climate.copernicus.eu/climate-indicators/temperature>.

Aggregated projections of emissions growth mask major divergences between countries. While emissions in advanced economies have generally peaked and are now on declining pathways, emerging markets and developing economies (EMDEs) continue to see rising emissions, driven by economic growth, industrial expansion, and increasing energy demand. In 2023, EMDEs accounted for approximately two-thirds of global GHG emissions, and their share is expected to grow further as they drive much of the increase in global emissions. Clearly, global climate neutrality cannot be achieved without a much more aggressive mitigation strategy in these regions.

The core challenge is not simply decarbonisation but, as these relatively poor countries want to grow and reduce poverty, how to ensure that economic development occurs through low-carbon pathways. Electrification – primarily through renewable energy deployment – is now more technically and economically feasible than ever. However, many EMDEs still rely heavily on fossil fuels for industrialisation and urbanisation as they are often constrained by the higher capital intensity of green technologies, limited access to capital for green investments, and weaker institutional frameworks for enforcing climate policies. If current trends continue, climate neutrality will be unattainable. Even before the Trump administration embarked on a complete reversal of US climate policy, the risks of derailing the green transition were material.

## 1.2 The future of climate mostly depends on emerging countries

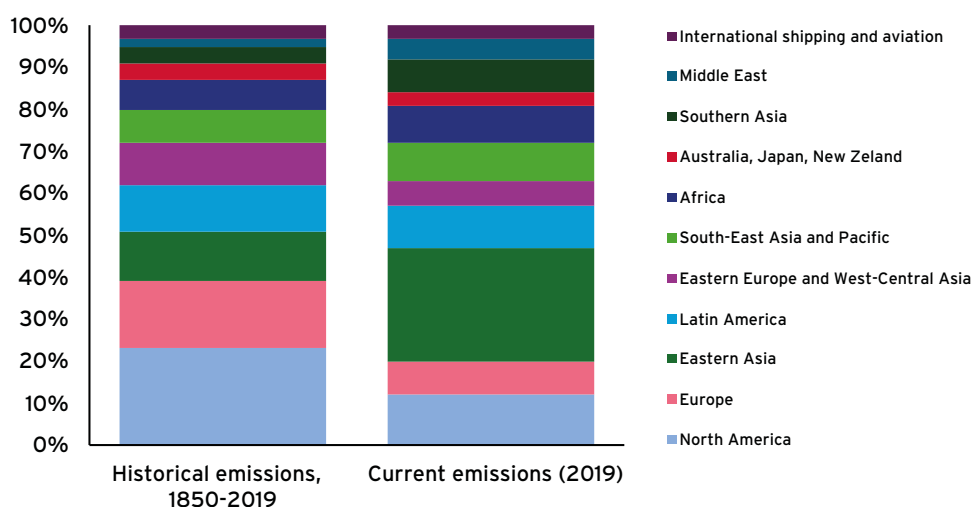
Without strong international cooperation, increased financing for clean energy, and robust policy incentives to accelerate renewable deployment in these regions, global net zero targets will remain out of reach. In essence, while advanced economies must continue their own decarbonisation efforts, they also have a strategic interest in supporting emissions reductions where they are growing fastest – otherwise, the effectiveness of their mitigation policies risks being undermined.

Continuing the path of current policies, global emissions are likely to remain above 60 GtCO<sub>2</sub>e (carbon dioxide equivalent) by 2050, far exceeding the reductions needed to achieve net zero emissions. This substantial gap emphasises the urgent need for enhanced policy interventions and technological innovation to meet international climate targets (IPCC, 2023b; see Appendix 1 for a sectorial analysis of the emission reductions required to reach net zero).

In this discussion, it is worth emphasising that two major economies – China because of its size and the United States because of its leading position – will play a decisive role in shaping the global mitigation outlook (Box 1). These two cases illustrate how national policies in key countries can significantly alter global emissions pathways.

Cumulative emissions point to the historical responsibility of advanced economies that have industrialised first. Together, countries of the European Union, the United Kingdom, and the United States are responsible for close to 50% of the historical stock of GHGs, amounting to around 561 GtCO<sub>2</sub>e (Friedlingstein et al., 2023). On the other hand, EMDEs, including much of Africa and Latin America, have historically contributed only a fraction of emissions (Figure 1).

FIGURE 1 HISTORICAL EMISSION STOCK VS CURRENT EMISSION FLOWS



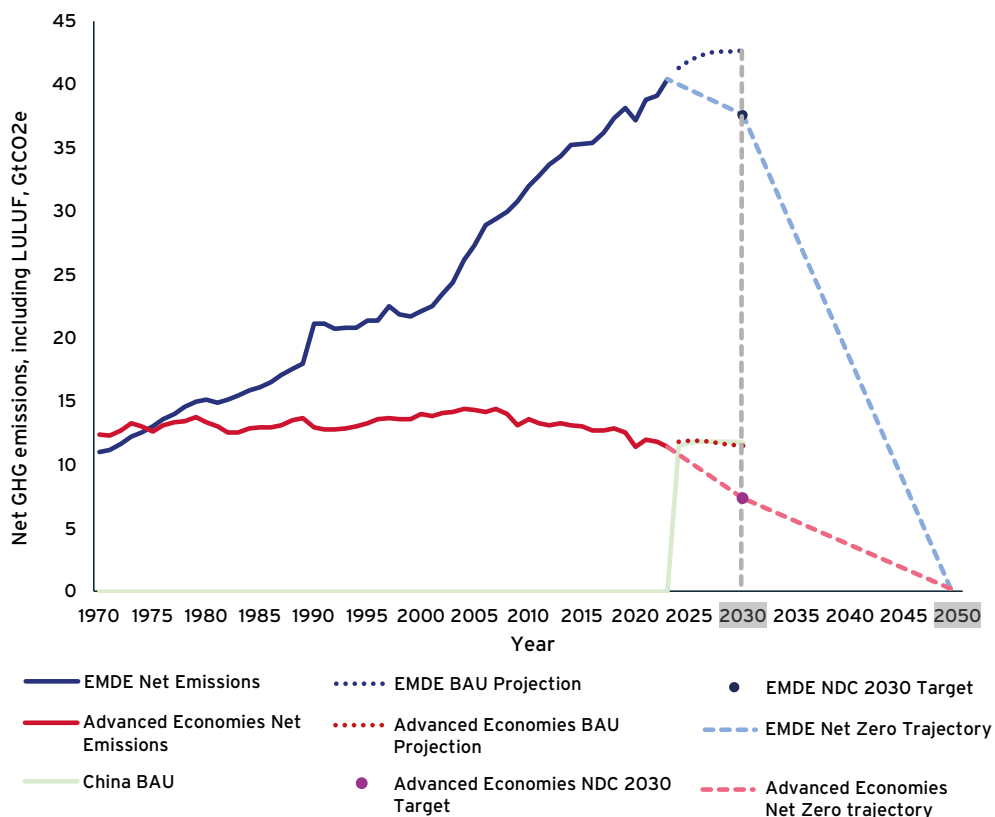
Source: Bruegel, based on Friedlingstein et al. (2023).

While historical emissions highlight the responsibility of advanced countries, current annual emissions emphasise where mitigation efforts are most urgently needed today. The global distribution of emissions has shifted dramatically over the last 30 years, as populations grow and EMDEs rely on coal and other fossil fuels for their energy consumption (UNEP, 2024). The biggest shift in emissions has been the transition from industrialised Western nations to rapidly developing economies in Asia: while the European Union and the United Kingdom contribute about 8% of global emissions, China is now the world's current largest emitter, producing close to 30% of GHG emission flows, or around 15.3 GtCO<sub>2</sub>e in 2023.<sup>5</sup> At current emission growth and sizes, China will soon be also among the biggest historical contributors to the increased stock of concentrated CO<sub>2</sub>e in the atmosphere, and India is not far behind.

5 Source: IMF Climate Change Dashboard (<https://climatedata.imf.org/pages/greenhouse-gas-emissions>). The estimate refers to total GHG emissions, including land use, land-use change, and forestry.

Chinese emissions may, however, peak soon (Box 1), whereas those of India, Indonesia, or South Africa are still rising fast. Under a business-as-usual scenario, advanced countries will account for 21% of global emissions in 2030, China for 22%, and the rest of the world for 57% (Figure 2). Whether or not the emerging countries succeed in curbing their emissions is thus vital for the future of climate.

**FIGURE 2 HISTORICAL EMISSIONS, 1970-2023, AND REQUIREMENTS FOR 2050**



Note: EMDEs includes China. The 2050 projection is given for EMDEs as a whole and not separately for China. Objectives for 2050 are not the official ones but those ensuring climate neutrality.

Source: Authors' calculations based on the IMF Climate Change Dashboard.

Assuming a linear reduction, emissions would need to decrease 5% yearly from 2030 to 2050. Under business as usual, this would mean EMDEs as a whole need to lower their annual emissions by around 2 GtCO<sub>2</sub>e every year; advanced economies require an annual reduction of around 0.6 GtCO<sub>2</sub>e.

### BOX 1 KEY PLAYERS SHAPING THE GLOBAL MITIGATION OUTLOOK

Two major economies stand out when discussing global emission projections:

**United States:** The recent policy shift under the Trump administration has put the country's decarbonisation trajectory in jeopardy. The announced withdrawal from the Paris Agreement in 2025, along with an emphasis on fossil fuel expansion under the "energy dominance" doctrine, is bound to slow down progress. The United States emitted 5.5 GtCO<sub>2e</sub> in total in 2023, and pre-presidential election projections indicated that emissions could decrease by around 40% to 3.3 GtCO<sub>2e</sub> by 2030. The announced energy policy reversal under the Trump administration casts uncertainty over the country's decarbonisation trajectory. Yet the extent to which federal policies will counteract state- and market-led clean energy transitions remains to be seen.

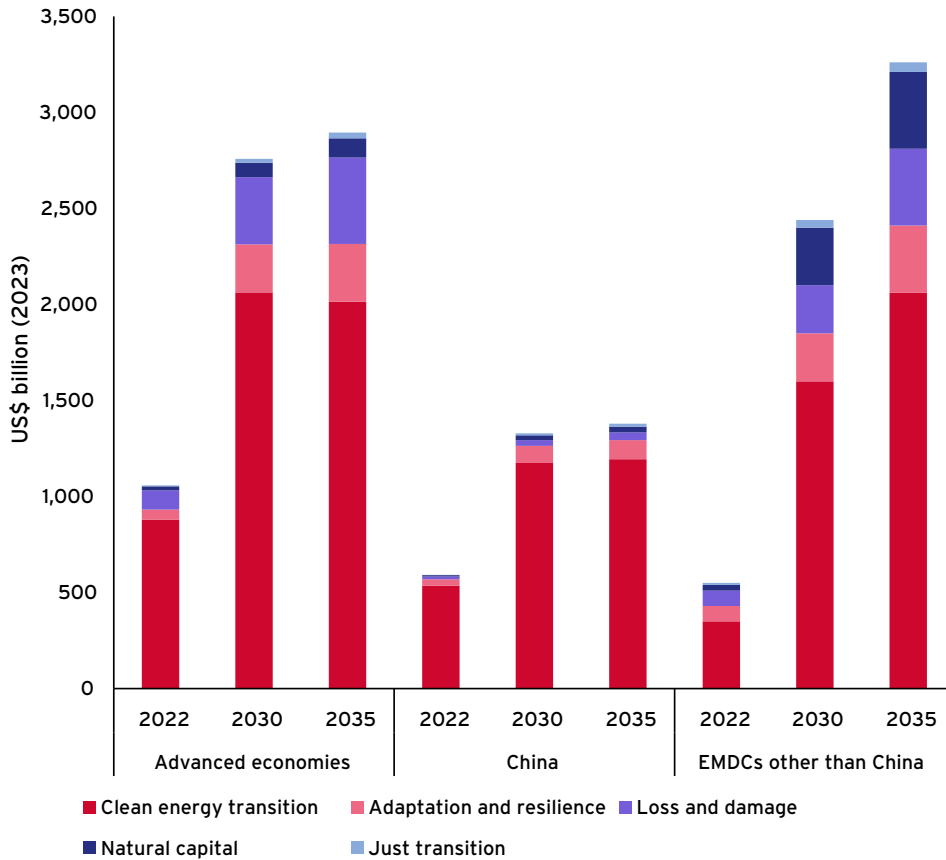
**China:** As the world's largest emitter, China plays a dual role in climate action. While its still-rising emissions remain high, it is also the leading driver of renewable energy deployment, with record-breaking investments in solar, wind, and electric vehicles. China's total emissions stood at 15.3 GtCO<sub>2e</sub>, but they may peak already in 2025 as its coal consumption is expected to decrease. Its success in transitioning toward carbon neutrality will significantly shape global emissions trends, making it a key determinant of whether net zero remains within reach.

### 1.3 Even if assessed conservatively, EMDEs' investment needs remain massive

Because green technologies are significantly more capital-intensive than brown ones, the reduction of GHG emissions requires massive investments; adaptation requirements only add to this tally. This fact applies to all countries, but emerging and developing economies tend to face a relatively higher investment gap compared with advanced countries and China, since the former start from a higher carbon intensity of output and need to grow faster to meet their development goals (see Chapter 2 by Luca Fornaro, Jean Pisani-Ferry, and Lucrezia Reichlin in this volume).

The series of reports provided by the Independent High-Level Expert Group (IHLEG) on Climate Finance, the latest of which was published in November 2024 (Bhattacharya et al., 2024), provide the most influential and widely used estimates of the investment needs "for delivery on the Paris Agreement". Their numbers are mind-boggling: across all economies (advanced economies, China, and EMDEs other than China), \$6.5 trillion of investments per year are needed by 2030, of which \$2.4 trillion are in the EMDEs other than China. In these economies, investments need to more than quadruple compared to the 2022 investment level (Figure 3). This amounts to a much higher required investment effort than in the advanced countries and in China.

**FIGURE 3 ANNUAL CLIMATE INVESTMENT NEEDS BY ECONOMIC REGIONS IN 2030 AND 2035**

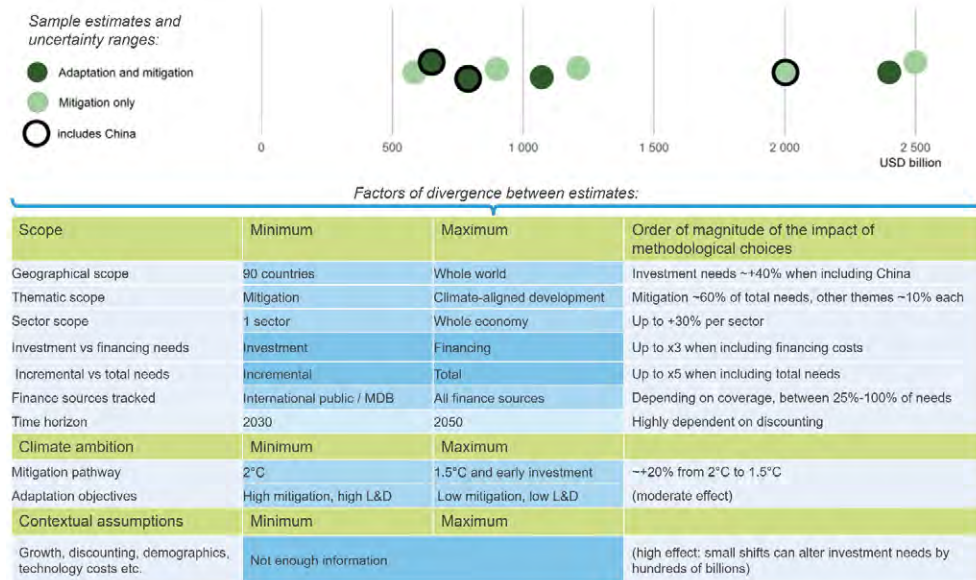


Source: Bhattacharya et al. (2024).

The IHLEG estimates top other existing assessments of investment needs in EMDEs, which range from \$500 billion to \$2,500 billion annually. This wide interval is in part attributable to differences in scope (as regards countries or the range of sectors covered), the type of investment considered (whether or not adaptation is included), and to whether all investment needs are considered, or only those externally financed. The width of the interval also results from discrepancies regarding the definition of investment needs (total or additional in comparison to a business-as-usual baseline) and the cost of capital.

Careful analysis by Arvis et al. (2025) documents the impact of each of these choices (Figure 4). Even the lowest estimates are far above current levels of US\$244 billion/year as reported by the CPI Global Landscape of Climate Finance 2024 (Naran et al., 2024).

**FIGURE 4 SAMPLE ESTIMATES AND UNCERTAINTY RANGES OF ANNUAL CLIMATE FINANCE NEEDS IN EMDEs BY 2030 AND FACTORS OF DIVERGENCE BETWEEN ESTIMATES**



Note: The gradient from light to dark blue reflects the importance of each factor on resulting estimates. Dark blue shows factors with the highest impacts.

Source: Arvis et al. (2025)

Alternative evaluations for the power sector, which accounts for 40% of total emissions in the EMDEs, are provided in Chapter 5 by Patrick Bolton and Alissa Kleinnijenhuis. The estimate of investment needs they come up with is still massive but significantly lower (about \$500 billion instead of \$1,600 billion for the IHLEG). This discrepancy is mostly attributable to a difference in scope and to whether total investment is considered, or only incremental investment (see Appendix 2 for details).

#### 1.4 The cost of capital adds to their investment burden

The other major difference is the much higher cost of capital in emerging countries. Table 1 gives rough estimates of this for selected large emerging countries. These numbers, based on estimates by the IEA,<sup>6</sup> indicate that in 2021, the real cost of capital for projects of the same nature (in the case reported in Table 1, a utility-scale solar PV) ranged from 3% in Europe and the United States, to 7% in India and Mexico, and more than 9% in Brazil.

6 <https://www.iea.org/reports/cost-of-capital-observatory/dashboard-2>

TABLE 1 COST OF CAPITAL IN SELECTED COUNTRIES, 2021

	Europe	US	China	Brazil	India	Indonesia	Mexico	South Africa
<b>Capital cost (\$/kW)</b>	815	1030	610	825	565	985	800	1070
<b>Nominal</b>	4.0%	4.3%	4.9%	13.1%	9.9%	7.2%	7.1%	10.0%
<b>Real</b>	3.0%	3.2%	4.0%	9.4%	7.2%	8.2%	7.1%	6.4%
<b>LCOE (\$/MWh)</b>	46	50	39	79	34	111	51	69

Source: IEA (2023).

A gap of this magnitude translates into a significantly higher levelised cost of electricity (LCOE) in emerging countries, offsetting in most cases the natural advantage of greater exposure to sun.

Many factors account for the higher cost of capital in emerging countries. Besides the higher country risk premia (Persaud, 2023), a host of regulatory, prudential, and other policy factors prevent the pool of advanced countries' savings from financing the energy transition in the South. Pervasive risk aversion also contributes to limiting the financing of Southern investment by Northern savings. At the same time, structural impediments hamper the channelling of those savings to worthwhile projects.

The combination of high investment needs and a high cost of capital acts as a major deterrent to the climate transition in the South. Despite the Baku commitment to foster North–South climate finance flows of about \$300 billion annually, actual flows remain much lower. The latest available estimates, for 2022, barely exceeded \$100 billion.

## 2 THE CHALLENGE OF PRESERVING NATURE

The protection of nature and biodiversity shares a number of similar challenges with the fight to limit climate change. First, just as climate change creates significant costs to our economies (e.g., Bilal and Känzig, 2024; Kotz et al., 2024), so does nature loss (e.g., Dasgupta, 2021; Ranger et al, 2023).

Second, just as with climate change, the effects of nature loss are non-linear. While some increase in temperature can be managed relatively well, larger increases reach tipping points in climate systems, leading to runaway dynamics for global temperatures. Similarly, for biodiversity losses, ecosystems can cope with small and local losses of biodiversity, but as biodiversity losses increase, ecosystems can collapse – causing loss of essentials for life such as water and fertile soil.

Third, as with climate change, there is a clear North–South divide in biodiversity. Key biodiversity centres that are of global relevance are outside advanced economies, where nature has already been severely reduced by industrialisation. And while advanced economies have historically been the main drivers of the increase in the atmospheric concentration of CO<sub>2</sub> and biodiversity losses, it is emerging economies that hold the key to both emissions reductions and biodiversity preservation.

Finally, biodiversity and climate protection are mostly complementary (as discussed in more detail in Section 3.3). Nature protection supports natural carbon sinks – to the benefit of climate protection. Conversely, destruction of biodiversity biomes can release substantial amounts of GHGs.

Yet, despite these parallels and similarities, there are also important differences between climate and nature when it comes to the structure of the public goods problem that must be addressed. With climate change, a truly global tragedy of the commons problem continues to be in search of a viable solution. As any GHG emissions anywhere in the world contribute equally to climate change, mitigation measures benefit the entire world – while the cost of decarbonisation is local and varies significantly across countries. This is fundamentally different with biodiversity protection: while there is an important global dimension – for example, when it comes to genetic biodiversity that may be useful for the development of future medicines or marine biodiversity supporting life in vast oceans – there is also a strong local dimension. National parks, for example, benefit local wildlife and local populations. The protection of farmland from excessive use of pesticides supports local biodiversity, improves water quality, and protects pollination services by insect populations, maintaining agricultural yields.

## **2.1 Alongside climate change, nature loss is a major global threat**

Nature is essential to the economy because it underpins ecosystem services, which are the “ecological processes or functions which have value to individuals or society”.<sup>7</sup> Biodiversity enables nature to be productive, resilient, and adaptable (Cardinale et al., 2012) and therefore to provide ecosystem services like pollination services by bees essential for agricultural yields, soil fertility for food production, genetic diversity useful for the development of medicines, carbon storage, and water and air filtration. The economy relies on these ecosystem services, but precise calculations are difficult to make because conventional accounting systems – including measures such as GDP – do not adequately take into account their value and the economic losses when nature can no longer provide these services.

7 Source: IPCC Glossary of Terms (<https://www.ipcc.ch/site/assets/uploads/2018/03/wg2TARannexB.pdf>).

There is a wide range of methodologies behind estimates of the losses and the value of the economic benefits provided by biodiversity. A recent calculation puts the annual economic costs of nature loss and ecosystem damage at \$5 trillion (Ranger et al., 2023). A major United Nations-led scientific nexus assessment found that more than half of global GDP – more than \$50 trillion of annual economic activity around the world – is moderately to highly dependent on nature.<sup>8</sup>

Another way of conceptualising this issue is to estimate the overall value of the annual flow of ecosystem services, which Costanza et al. (1997) found to be larger than world GDP. A more recent calculation arrives at a sum of over \$150 trillion annually, twice the size of global GDP (Kurth et al., 2021). This range is partly because many of the services that nature provides for free are very expensive to replace with human technology (for example, desalination of water or hand-pollination of plants) and some cannot be substituted by human technology (for example, DNA for new medicines), so it is hard to estimate their value or the impact of their loss.

Quantifications are less important, however, than the fact that if biosphere services were at zero, humanity would not exist. Looking at a smaller level of aggregation, pollination services are worth €153 billion a year – affecting almost 10% of the global production of human food (Khalifa et al., 2021) and nearly all of the vegetables and fruit that humans eat. An estimate of the value of one ecosystem service to one country – namely, pollination services in the United Kingdom – found that this service was worth only \$500-600 million (Breeze et al., 2011), which is negligible as a percentage of GDP. But while its contribution to GDP may be small, the absence of pollinator services would reduce GDP by more than this amount because multiple ecosystem services would be at risk of collapsing. These major non-linearities mean that nature loss leads to huge economic losses once tipping points are reached beyond which nature can no longer provide ecosystem services that are vital for life (such as clean air and water, or food). Even before reaching those tipping points, nature loss results in loss of medicines globally and local losses of crops and water provision.

The five direct drivers of change in nature over the past 50 years are, in order of impact, changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasion of alien species (IPBES, 2019). These factors have diminished and fragmented the earth's ecosystems, as well as eroding the ability of nature to provide ecosystem services.

The speed at which ecosystem services are being eroded is uncertain, and is complicated by the existence of planetary boundaries which, when breached, can lead to abrupt and irreversible changes in earth systems (Richardson et al., 2023). Several biomes – such as the Amazon rainforest – are approaching key thresholds. There is evidence that the

8 See [https://knowledge4policy.ec.europa.eu/publication/ipbes-thematic-assessment-report-interlinkages-among-biodiversity-water-food-health\\_en](https://knowledge4policy.ec.europa.eu/publication/ipbes-thematic-assessment-report-interlinkages-among-biodiversity-water-food-health_en)

Earth is reaching tipping points across ecosystems – such as in forest dieback, dryland desertification, lake eutrophication, and collapse of fisheries – causing major loss of biodiversity, affecting regional rainfall patterns, and increasing GHG emissions (Lenton et al., 2023).

## 2.2 The scale of financing needed is much larger than what is currently available

Approximately \$200 billion goes into protecting and restoring nature each year, most of which is from public sources (Bromley, 2024). This contrasts with current economic and financial drivers that incentivise investment in activities that damage biodiversity, estimated at approximately \$7 trillion per year (UNEP, 2023). This is dominated by private sector financial flows, of which \$5.3 trillion annually directly damages biodiversity, while public subsidies that incentivise this damage are estimated at \$1.7 trillion.<sup>9</sup>

In 2022, the United Nations Biodiversity Conference of Parties (COP) produced the Kunming-Montreal Global Biodiversity Framework, which calls for countries to halt and reverse biodiversity loss by 2030 and to raise an additional \$700 billion per year to do so. This \$700 billion ‘funding gap’ comprises the elimination, phase out, and reform of at least \$500 billion per year in harmful subsidies (Target 18), and the mobilisation of \$200 billion (Target 19) through all sources, including Official Development Assistance, private finance, and innovative schemes like payment for ecosystem services, green bonds, biodiversity offsets, and credits.<sup>10</sup>

BloombergNEF<sup>11</sup> calculated that, as of 2024, additional funding of \$942 billion was needed by 2030 to achieve key goals (Figure 5). The overall \$1.15 trillion per year target constitutes \$229 billion for protected areas and \$87 billion for urban areas. The majority of this gap (\$834 billion) is needed for productive landscapes and seascapes such as croplands, combatting invasive species, and forests and fisheries. The current \$208 billion is dominated by public spending (83%), which was mostly spent on conservation, sustainable agriculture, forestry and fishing, wastewater management, and pollution abatement.

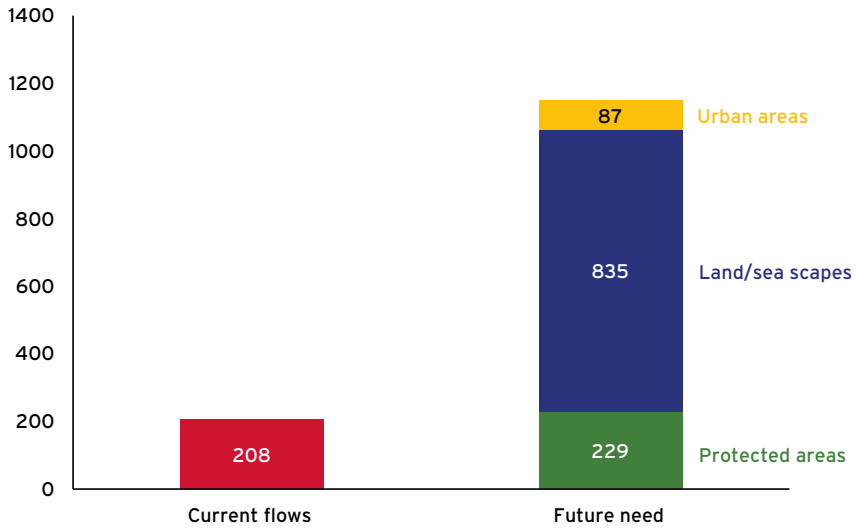
9 See [https://knowledge4policy.ec.europa.eu/publication/ipbes-thematic-assessment-report-interlinkages-among-biodiversity-water-food-health\\_en](https://knowledge4policy.ec.europa.eu/publication/ipbes-thematic-assessment-report-interlinkages-among-biodiversity-water-food-health_en)

10 See the Convention on Biological Diversity 2030 Targets (<https://www.cbd.int/gbf/targets>).

11 See Bromley (2024).

**FIGURE 5 BIODIVERSITY FINANCE FLOWS**

Current annual biodiversity finance flows vs biodiversity conservation funding needs by 2030, USD billion



Source: BloombergNEF (Bromley 2024).

### 3 CLIMATE AND NATURE: COMPLEMENTARITIES AND DIFFERENCES

The mitigation of climate change and the preservation of biodiversity are both covered by an international framework agreements and subject to organised monitoring. As indicated in Table 2, which summarises the essential features of the global climate and biodiversity agreements in force, those agreements have much in common. Both combine a global primary aim, headline targets for the medium term, and voluntary national action plans. Both are also buttressed by commitments to mobilise financial resources in the North. In fact, the Kunming-Montreal framework was visibly inspired by the Paris Agreement.

There are also differences between the climate and biodiversity frameworks, the most salient being that biodiversity targets are not defined by a single metric whereas the climate targets are. The order of magnitude of the planned effort is also not the same, as the biodiversity target for North–South finance flows is one-tenth of the (recently updated) target for climate.

TABLE 2 ESSENTIAL FEATURES OF GLOBAL CLIMATE AND BIODIVERSITY AGREEMENTS

	Paris Agreement (2015)	Kunming-Montreal Framework (2022)
<b>Primary aim</b>	Limit global warming to well below 2°C, preferably 1.5°C above pre-industrial levels	Halt and reverse biodiversity loss
<b>Headline targets</b>	Peak global emissions of GHGs as soon as possible Achieve climate neutrality in the second half of the century	Protect 30% of land and sea areas and restore 30% of degraded ecosystems by 2030
<b>National implementation</b>	Nationally determined contributions (NDCs) Requirement to submit increasingly ambitious NDCs every 5 years	National Biodiversity Strategies and Action Plans
<b>Financial commitments</b>	Mobilise \$100 billion annually for developing countries (increased to \$300 billion in 2025)	Mobilise \$200 billion per year from all sources and increase international flows to developing countries to \$30 billion annually
<b>Monitoring and reporting</b>	Global stocktake every five years	Headline indicators for tracking progress Regular national reporting requirements
<b>Market mechanisms</b>	International carbon markets within the framework of Art. 6	Payment for ecosystem services Biodiversity offsets and credits Natural capital accounting

### 3.1 Whilst climate change is global, biodiversity has a strong local dimension

Protecting biodiversity is essential everywhere, since local biodiversity underpins local ecosystem services. However, unlike carbon dioxide in the atmosphere, species and ecosystems are not evenly distributed around the planet. Drivers of biodiversity change are also unequally distributed across the world (Bowler et al., 2020). There are 36 ‘biodiversity hotspots’ in the world,<sup>12</sup> which together represent 2.5% of the planet’s land surface but support more than 50% of the world’s endemic plant species and almost 43% of indigenous bird, mammal, reptile, and amphibian species.<sup>13</sup> Hotspots are also home to many vulnerable human populations – providing 35% of the ecosystem services that these populations depend on. According to the IPCC (2022), there is a very high extinction risk for endemic species in biodiversity hotspots, and this risk increases at least tenfold if warming rises from 1.5°C to 3°C.

12 Definition of biodiversity hotspots: (1) irreplaceable (must have >1500 vascular plants as endemics); and (2) threatened (must have 30% or less of its original vegetation).

13 “Biodiversity Hotspots”, Conservation International (<https://www.conservation.org/priorities/biodiversity-hotspots>).

### 3.2 Towards joined-up funding for climate change mitigation and biodiversity conservation in the Global South

The central findings of this short literature review suggest a focused effort on frontloaded funding for the benefit of biodiversity hotspots and climate change mitigation support in emerging economies. Most biodiversity hotspots at risk can be found in emerging economies in the Global South, particularly in tropical regions such as Central and South America, Africa, and Southeast Asia. The increase in GHG emissions is also strongest in some of these regions, as economic growth remains fossil-fuel based and neglects nature protection. Given the presence and value of, as well as the threat to, these hotspots, much greater financing is needed from rich countries. The uncertainty in the face of such crucial processes, as well as their non-linear impact, mean that it is essential to frontload the protection of nature. International public biodiversity finance from developed to developing countries is also important in ethical and symbolic terms to recognise historical and current responsibility for biodiversity depletion (Pettinotti et al., 2024a).

Target 19 of the UN Convention on Biodiversity calls for \$20 billion per year in international financial resources from developed countries by 2025, rising to \$30 billion by 2030. Pettinotti et al. (2024a) found that the overwhelming majority of developed countries do not pay even half of their fair share of biodiversity finance, with only Norway, Sweden, and Germany reaching half in 2022 (Pettinotti et al., 2024b).

Based on biodiversity presence, value, and threat, BloombergNEF ranks Brazil, China, Indonesia, Democratic Republic of Congo, and Colombia as the highest priority regions for biodiversity funding. Countries with lower income and higher economic instability tend to be priority regions for biodiversity funding (Bromley, 2024). Only 1% of public biodiversity finance was spent on Official Development Assistance.

### 3.3 Actions on climate and action on nature are mostly complementary

Nature and climate are inextricably linked: climate change is a driver of biodiversity loss, and nature loss drives climate change. The IPCC (2022) calculates that risks to terrestrial ecosystems will rise incrementally with global warming. Likewise, biodiversity loss reduces an ecosystem's potential to sequester carbon (Weiskopf et al., 2024). Therefore, action on both climate and nature is essential.

However, climate and biodiversity solutions are not always complementary, because the extension of renewable electricity production often takes place at the expense of the preservation of nature and because some nature-based carbon extraction solutions are not good for biodiversity while, on the other hand, some conservation measures may benefit biodiversity (and carbon storage) but contribute little towards carbon removal.

However, even if there are trade-offs between solutions, the problems are closely interlinked. The faster and the more the climate changes, the harder it is for ecosystems to adapt, causing loss of more habitats and species. Similarly, the larger the scale of destruction of nature, the more carbon will be released and the harder it will be to deal with the local effects of climate change (for example, because of loss of the cooling effects of forest cover and its role in water production). For this reason, nature-based solutions for climate change mitigation are important, but the protection of nature cannot rely solely on such efforts. Public funding solutions are necessary as voluntary carbon markets, which often have biodiversity co-benefits, suffer from lack of trust and scale (as shown in Chapter in 8 by Cantillon, Lambin, and Weder di Mauro). Specific international funding for the conservation of systemically important ecosystems will be needed, in addition to dedicated national funds.

On the whole, frontloaded funding for nature conservation and for climate protection in the global South should go hand in hand. Both need to be frontloaded due to major non-linearities. Both need to be targeted to the global South owing to its larger role in determining the future trajectories of both nature and the climate.

## **4 ADVANCED COUNTRIES HAVE A DIRECT INTEREST IN SUPPORTING THE SOUTH**

### **4.1 Recent US developments take the world further away from cooperative solutions...**

Decisions announced since 20 January 2025 leave no doubt regarding the hostility of the United States towards global climate action. The Executive Order “Unleashing American Energy” was signed by President Trump on the very day of his inauguration and every act that has followed – including, obviously, the US withdrawal from the Paris Agreement – has been in accordance with this initial statement of intent. For reasons that have to do with substance as well as with process, collective action in support of climate epitomises what the Trump administration hates the most. Moreover, it regards action on climate by the Bretton Woods institutions as ‘mission creep’ and intends to refocus them on core missions (Bessent, 2025).

This is worrying, given that more than 40% of World Bank loans support climate change mitigation and that the United States has a strong (often critical) influence on the governance of the Bretton Woods institutions. Whether the World Bank and the International Monetary Fund renege on their present commitment to support climate action, or merely become less vocal, will largely depend on the ability of Europe to make use of the strength it has in these institutions.

## 4.2 ... but large countries may find it beneficial to individually fund the South

Decarbonisation costs tend to be significantly lower in the South than in the North, whilst benefits accrue evenly to all countries. The structure of the Paris Agreement, however, makes each country primarily responsible for reducing its own emissions, irrespective of the abatement cost.<sup>14</sup> From a social planner's viewpoint, this arrangement is inefficient: as the marginal abatement cost is at least twice as high in the advanced countries as it is in China, and at least three times as high as in India, everyone would gain from Northern support for Southern decarbonisation (Black et al., 2024). Even a partial arrangement would yield significant benefits.

This applies also to biodiversity, as part of the potential long-term global benefits of preserving nature accrue to countries of the North. Because spillovers tend to be local, the distribution of those benefits may be skewed in favour of the country taking action and its direct neighbours, but part of those benefits are global in essence. For example, the benefits of preserving sources of future medicines accrue to the whole world.

## 4.3 Europe can help by building a coalition of the willing

The openly hostile attitude of the Trump administration renders the search for cooperative global solutions problematic. The United States, however, is a secondary player as regards climate and the preservation of nature. Europe and like-minded countries could build 'coalitions of the willing' (Blanchard and Pisani-Ferry, 2025) that would preserve the incentive for the North to finance action in the South.

Recent research actually leads to lowering the threshold at which such coalitions are potent enough to justify action. Bilal and Känzig (2025) estimate that broad unilateral decarbonisation would benefit large countries like the United States or large entities like the European Union. As marginal abatement costs are lower in the South than in the North, this finding implies that coalitions of the willing would benefit even more from joint decarbonisation. The implication for Europe is that, by building a coalition of the willing, it could overcome the tragedy of the commons resulting from the US withdrawal from the Paris Agreement.

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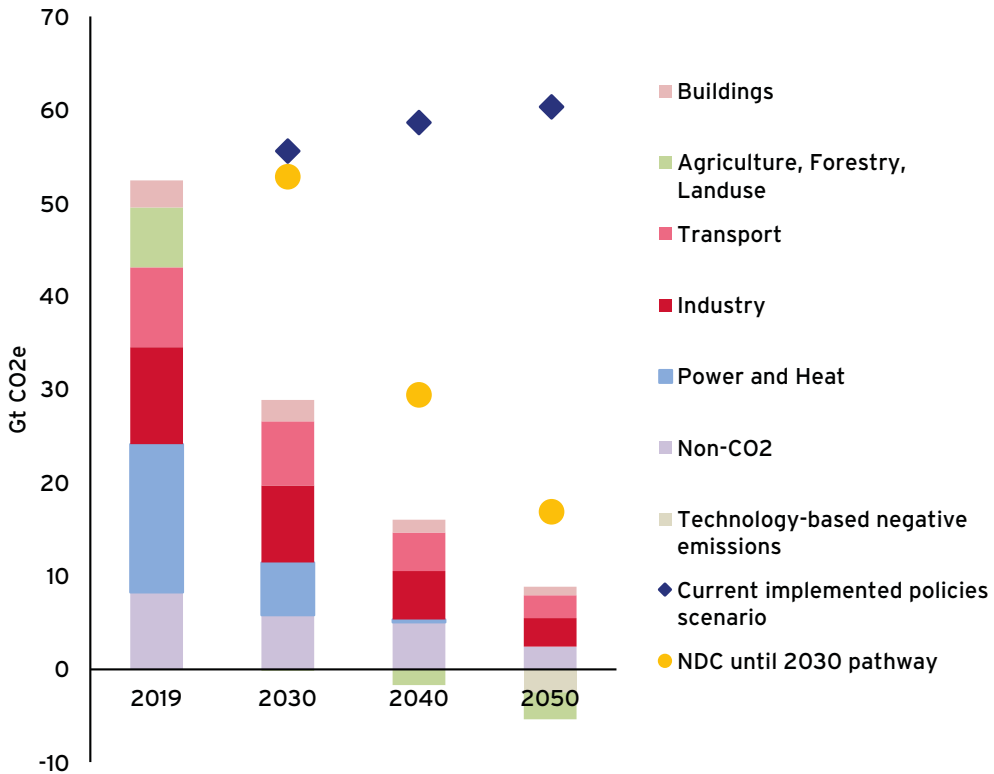
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## APPENDIX 1 GLOBAL GHG EMISSIONS REDUCTION REQUIRED TO REACH NET ZERO: A SECTORIAL ANALYSIS

Continuing the path of current policies, global emissions are likely to remain above 60 GtCO<sub>2</sub>e by 2050, far exceeding the reductions needed to achieve net zero emissions (Figure A1). This substantial gap emphasises the urgent need for enhanced policy interventions, technological innovation, and accelerated adoption of sustainable practices to meet international climate targets (IPCC, 2024).

FIGURE A1 EMISSION REDUCTIONS NECESSARY TO REACH NET ZERO



Note: Emissions figures for 2019 are derived from the EDGAR database, with reduction percentage factors for each sector applied according to the IPCC sectoral split. The IPCC pathway of reference is pathway subset 50, aligning with a scenario limiting warming to 1.5°C with a >50% likelihood and no or limited overshoot. The NDC until 2030 pathway refers to pathways with GHG emissions until 2030 associated with the implementation of NDCs announced prior to COP26, followed by accelerated emissions reductions likely to limit warming to 2°C (with probability 67%) or to return warming to 1.5°C with a probability of 50% or greater after high overshoot.

Source: Bruegel on EDGAR and IPCC.

Achieving net zero requires transformative actions across multiple sectors. For the power and heat sectors, close to net zero emissions by 2040 could be achieved through scaling up renewable energy, improving grid efficiency, and deploying carbon capture and storage (CCS) technologies in combination with fossil fuels. With regards to renewable energy, increasing wind and solar capacity will be crucial, alongside investment in smart grids and energy storage to ensure reliability (IPCC, 2023b). In Europe, increasing capacity for cross-border electricity transmission could deliver substantial efficiency gains (Dimopolous et al., 2023).

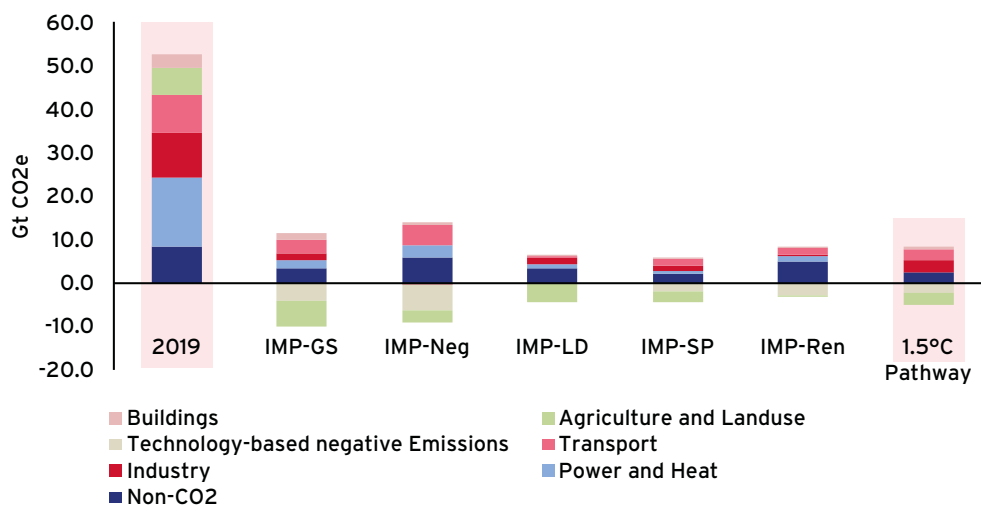
For agriculture, forestry, and land use, reaching net zero by 2030 would involve large-scale reforestation efforts, soil carbon sequestration initiatives, and substantial reductions in deforestation. Restoring forests and improving land management practices could provide 20% to 30% of the climate change mitigation needed to limit global warming to 1.5°C. These changes must be supported by financial incentives and capacity-building in developing regions, which host most global forests (IPCC, 2023b).

Post-2040, compensating for residual emissions will require the rapid scaling of negative emissions technologies and nature-based solutions. Technologies such as bioenergy with carbon capture and storage (BECCS) or direct air capture (DAC), along with nature-based approaches like afforestation, are critical to achieving this balance. Without upscaling these technologies, unprecedented energy demand reductions would be required to stay within the 1.5°C goal (IEA, 2020).

### Different IPCC scenarios to reach net zero

The basis for the quantified emission reductions per sector are aggregations of scenarios and climate models corresponding with the 1.5°C target. They are based on a likelihood of achieving that target of at least 50% (Figure A2).

FIGURE A2 ILLUSTRATIVE MITIGATION PATHWAYS AND 1.5°C POLICY SCENARIO



Note: The IPCC outlines various trajectories on how net zero could be reached and calls them IMPs (Illustrative Mitigation Emissions Pathways). These pathways focus on varying degrees of integration of renewables (high integration with IMP-Ren) or deployment of technology-based direct-air capture of CO<sub>2</sub> (IMP-Neg). The large number of different scenarios form the input for the highlighted 1.5°C pathway. The Emissions in 2019 in this graph stem from the EDGAR database. The sectoral emission reductions for each scenario are derived from the IPCC and applied to the EDGAR data. Positive emissions from Power and Heat are absorbed by technology-based-negative emissions, and thus not shown in the 1.5°C pathway.

Source: Bruegel on EDGAR and IPCC.

The IPCC further makes use of 'Illustrative Mitigation Pathways' (IMPs), which showcase different emission trajectories based on global (policy) choices. These pathways are based on the outputs of various scenario modelling exercises and show how packages of policy choices transform relevant sectors while keeping warming to >2°C or 1.5°C. Five prominently used IMPs illustrate the composition of emission per sector once net zero is achieved. The various foci of these IMPs to achieve net zero are high renewable integration, the extensive deployment and use of carbon removals, gradual strengthening of current policies, lowered demand, a shift towards overall sustainable development, fossil phase-out, and reduced inequality. They showcase the trade-offs accompanying policy choices (IPCC, 2023a).

## APPENDIX 2 COMPARISON BETWEEN IHLEG AND BOLTON-KLEINNIJENHUIS INVESTMENT ESTIMATES

Projections by Bolton and Kleinnijenhuis in Chapter 5 of this volume, which are based on granular data on the GHG emissions of 126,000 power plants located in 143 countries, provide an alternative to the IHLEG estimates. Table A1 compares the respective estimates of the two sources, focusing on the energy sector.

TABLE A1 COMPARISON BETWEEN IHLEG AND BOLTON-KLEINNIJENHUIS INVESTMENT ESTIMATES

	IHLEG 2024	Bolton-Kleinnijenhuis 2025
<b>Time period</b>	2030	Annual average 2024-2035
<b>Country coverage</b>	EMDEs excl. China	EMDEs excl. China
<b>Temperature target (2100)</b>	1.5° (IEA)	1.5° (NGFS)
<b>Scope</b>	Gross investment cost of decarbonisation of the energy sector and energy-related SDGs	Cost of power sector decarbonisation (investment cost plus opportunity cost of early retirement of fossil fuel plants)
<b>Incremental/total needs</b>	Total	Incremental
<b>Total costs/external financing</b>	Total needs	Total needs
<b>Approach</b>	Hybrid	Bottom-up
<b>Headline figure</b>	\$1600 billion	\$465 billion

Sources: Bhattacharya et al. (2024); Arvis et al. (2025); Chapter 5 by Bolton and Kleinnijenhuis.

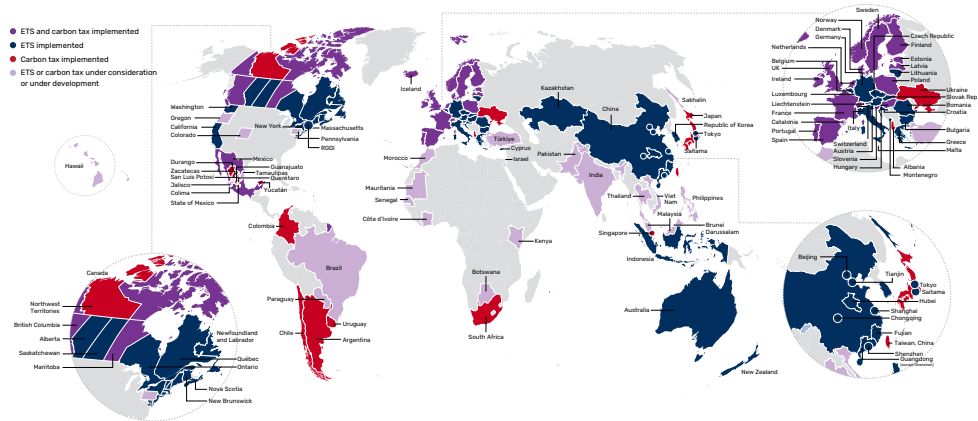
For the EMDEs excluding China, Bolton and Kleinnijenhuis put total investment needs at about \$0.5 trillion per year 2024-2035, against \$1.6 trillion by 2030 for the IHLEG. This large gap can be ascribed to three factors. The first relates to scope: the IHLEG report focuses on climate- and development-related investments, including those needed to reach the Sustainable Development Goals (SDGs), while Bolton and Kleinnijenhuis focus on the sole decarbonisation of the power sector. The second is that the IHLEG considers total investments whereas Bolton and Kleinnijenhuis only consider the additional investments required for decarbonisation. The third is the time period considered (Bolton and Kleinnijenhuis average annual investments over 2024-2035, while the IHLEG provides a point estimate for 2030).

## APPENDIX 3 CLIMATE POLICY TOOLKITS IN USE

Bridging the gap to net zero will depend on coordinated global efforts, sustained investment in green technology, and policy alignment across countries. As they stand, current climate policy frameworks differ widely across countries, reflecting varying economic structures, political priorities, and environmental challenges (Figure A3).

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FIGURE A3 MAP OF DIFFERENT CARBON TAXES AND EMISSIONS TRADING SYSTEMS ACROSS THE WORLD



Source: World Bank.

Today, there are 75 carbon pricing mechanisms,<sup>15</sup> covering almost 24% of global emissions (compared to just above 5% in 2010), yet they vary greatly in terms of sector coverage. For example, the EU's Emissions Trading System (EU ETS) has cut emissions from power plants and industry by 47% since its introduction in 2005.<sup>16</sup> Other nations, such as China and Brazil, are only beginning to expand their emissions trading systems.

The price of carbon also varies widely across schemes, ranging between \$0.46 and \$167 per tonne. Currently, just 1% of global emissions are priced above the recommended level,<sup>17</sup> and none reach the social cost of carbon (SCC) – a reference point to describe the cost incurred by the damage caused by the emission of one extra tonne of carbon. Rennart et al. (2022) estimate the SCC to lie at \$185, and the IMF estimates that only a global carbon price of \$75 will suffice to keep warming below 2°C. Both numbers are in stark contrast to the average CO<sub>2</sub> price, which lies at around \$3 per tonne of emissions (Parry, 2021).

15 Thirty-six emissions trading systems and 39 carbon tax schemes.

16 See [https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/what-eu-ets\\_en](https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/what-eu-ets_en)

17 Source: World Bank Carbon Pricing Dashboard (<https://carbonpricingdashboard.worldbank.org/compliance/coverage>).

Regulatory measures and subsidies are another prominent feature of national strategies. The European Union's regulatory framework includes standards, for example, for vehicles and buildings (Council of the European Union, 2024), and the UK government is substantially increasing subsidies for offshore wind.<sup>18</sup>

The disparity in decarbonisation speeds resulting from these different approaches among countries complicates efforts to maintain a level playing field in international trade. Nations rapidly reducing their emissions may face competitive disadvantages compared to those with less stringent policies. Measures like the EU Carbon Border Adjustment Mechanism (CBAM) have been introduced to deal with such challenges. The mechanism imposes levies on imports based on the emissions generated in its production and tied to the EU carbon price. This is aimed at preventing carbon leakage and ensuring fair competition.<sup>19</sup> However, such measures may spark trade tensions, underscoring the need for global carbon pricing agreements to harmonise efforts and reduce conflicts.

18 "UK government to increase offshore wind subsidies by 66%", *Financial Times*, 16 November 2023 (<https://www.ft.com/content/cb351788-377b-4ea7-aa0a-9bcc28293e7d>).

19 See [https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism\\_en](https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en)

# The green transition: Challenging for all, but even more for middle-income countries

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The transition to net zero entails a major transformation of the economic system and will affect developing as well as advanced economies, with consequences for growth, inflation, and public finances. However, these consequences will differ across countries and over time, depending on initial conditions and policy frameworks. This chapter explores how development levels and policy choices affect the nature of, and the obstacles to, the required transformation. Drawing on Fornaro et al. (2025) and Pisani-Ferry and Mahfouz (2023), Section 1 discusses a framework for understanding reallocation costs associated with the transition. Section 2 analyses implications for monetary policy. Section 3 discusses how demand and supply changes may affect the equilibrium interest rate. Section 4 presents implications for developing and emerging economies. Section 5 summarises policy implications.

## 1 REALLOCATION COSTS IN THE TRANSITION AND IMPLICATIONS FOR PRODUCTIVITY AND INFLATION

The macroeconomic impact of climate action operates through both the aggregate demand and aggregate supply sides of the economy. Because climate change mitigation requires investment, it has often been assumed that it would boost aggregate demand, thereby triggering an increase in output. But as developed in Pisani-Ferry (2021), this reading is misleading as it puts all the emphasis on the demand side of the economy, ignoring the adverse impact of the relative price of energy on aggregate supply.

### 1.1 The long-term outlook

Our starting point is the assumption that green technologies will eventually turn out more efficient than brown ones, meaning that in the aggregate, the same goods and services will be produced at lower cost. This is a hypothesis, not yet a fact, because although the evidence for it is increasingly strong (Turner, 2025), we do not know for sure to what extent it will apply, or at what horizon.

There will, moreover, be sectoral exceptions, such as air transportation services, where there is currently no *technical* substitute for fossil fuel-powered airplanes, or the production of steel and cement, for which *economic* conditions do not currently warrant the greening of production processes (McKinsey, 2022). But overall, efficiency gains from substituting green power for brown power will likely be large enough to pay for the storage of electricity and the extra cost of negative emission technologies.

While this transformation could take until 2050 and beyond, decarbonised energy is likely to be cheaper than brown energy by 2035, assuming producers can afford the corresponding investments.

At the same time, there will be transition costs linked to the replacement of the capital stock. As green technologies tend to be more capital-intensive than brown ones, the transition to a climate-neutral economy relies in large part on the substitution of capital for fossil fuels. The economic cost of the transition therefore depends on the ratio between the capital stock that must be replaced and total output.

## 1.2 The medium term: Reallocation costs

Let's start with supply effects. The main channel of decarbonisation is the substitution of one type of capital ('green') for another ('dirty') in a context in which the two types of capital are not perfect substitutes.

Eventually, substitution will reduce operating expenses, but in the short run it entails costs. As summarised by Pisani-Ferry and Mahfouz (2023), "decarbonisation is equivalent to putting a price on a resource – climate stability – that was previously available for free. Whether the pricing is explicit (in the case of carbon taxation) or implicit (if policy proceeds through regulation), this has a negative impact on the production potential of a given capital stock."

Pisani-Ferry and Mahfouz review the economic mechanisms that trigger the transition to net zero and conclude that the main one is the substitution of capital for fossil fuels. Consistent with other studies, they estimate that additional investment required to reach net zero in 2050 amounts in the French case to 2.3% of GDP annually. Importantly, most of these investments do not increase potential output. For this reason, the climate transition entails a temporarily negative aggregate supply shock.

The essence of this argument is not only that climate sustainability requires structural change and that, as in most processes of structural change, the transition of the economy to its new long-term equilibrium involves disruptions in production and a temporary decline in productivity. It is also that the transition is bound to increase the capital intensity of production because a climate-neutral economy is more capital-intensive.

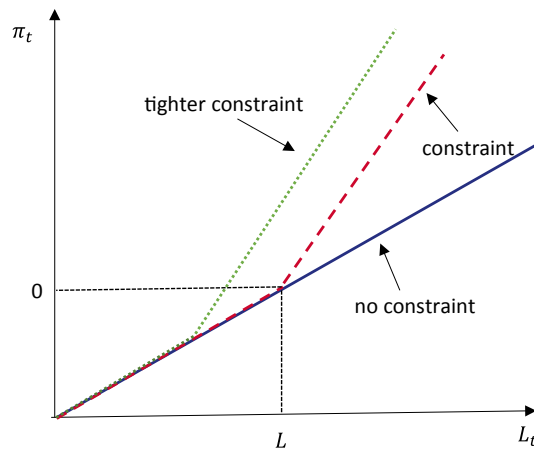
Fornaro et al. (2025) review empirical evidence on the size of these reallocation costs. A key reference is the work of Känzig (2023), who estimates that, in Europe, a tightening in the carbon emissions allowed by the EU Emissions Trading System (EU ETS) causes a decline in economic activity and employment, as well as an increase in inflation. Specifically, Känzig estimates that in the absence of supporting policy action, a 1% reduction in emissions (imposed by the EU ETS) causes a decline in industrial production of about 2%, an increase in unemployment of about 0.4 percentage points, and an increase in consumer prices of about 0.4%. Berthold et al. (2023) report similar results. These estimates confirm that tighter constraints on fossil fuel use act as negative supply shocks. Calculations by Fornaro et al. (2025), based on the effect of an unexpected change in the price of gas in Europe, point to similar results qualitatively. Since Europe is a net importer of gas, a shock to gas prices such as the one triggered by the war in Ukraine is similar to a tightening of the constraint on the use of gas in production.

Another useful guide to understanding transition costs comes from a 2022 McKinsey report that quantifies the costs associated with a scenario based on the assumption that coal production for energy use ends by 2050, while oil and gas production volumes become lower than today by about 55% and 70%, respectively. The analysis, which weighs both costs and opportunities, suggests that sectors with high-emissions products or operations (which today generate about 20% of global GDP) will suffer a large negative impact on demand, production costs, and employment. The report also concludes that process changes would increase production costs in other sectors, especially steel and cement, which would see increases by 2050 of about 30% and 45% percent, respectively.

From a macroeconomic standpoint, Fornaro et al. (2025) argue that reallocating economic activity out of dirty and towards clean technologies will cause an adverse shift of the aggregate supply curve. Intuitively, phasing out polluting technologies will increase, at least temporarily, firms' production costs, leading them to increase prices. This effect will be particularly strong in periods of high demand, during which regulatory constraints on the use of polluting technologies will bind. Therefore, we should expect that the green transition will steepen the aggregate supply curve for high levels of economic activity.

This is illustrated in Figure 1, which represents the relationship between inflation ( $\pi$ ) and economic activity, captured by employment ( $L$ ). The supply curve is kinked and gets steeper at high levels of economic activity (above  $\bar{L}$ ), because regulatory constraints on the use of dirty technologies boost firms' production costs in periods of high demand. The figure also shows the impact of a tightening of green regulations aimed at reducing carbon emissions. The supply curve shifts to the left, so that the steeper portion of the curve now corresponds to lower levels of employment and economic activity. The economy thus experiences a negative supply shock, worsening the trade-off between inflation and economic activity faced by the central bank.

FIGURE 1 THE IMPACT OF CLIMATE TRANSITION POLICY ON THE AGGREGATE SUPPLY CURVE



Source: Fornaro et al. (2025).

The key assumption here is that intermediate inputs are imperfect substitutes. The harder it is to substitute dirty inputs with clean ones, the greater the rise in the price of dirty goods during the green transition. As long as imperfect substitution holds, constraining the supply of dirty goods lowers labour productivity and triggers a rise in their price, since the lower labour productivity is accommodated through higher price inflation.

When the supply of dirty goods is constrained by regulation, their relative price increases, inducing a (desirable) reallocation of production towards clean goods. However, the rise in the relative price of dirty goods is also a source of inflationary pressures. To counteract these inflationary pressures, the central bank is bound to tighten monetary policy, thus reducing aggregate demand and output. This explains why – consistently with the evidence we have reviewed – tightening the regulatory caps on carbon emissions leads to a temporary drop in GDP and productivity.

This effect is larger the harder it is to substitute clean inputs for ‘dirty’ inputs. The size of the substitution effect depends on the sector, and therefore it is likely to affect countries in different ways. In developed countries, the elasticity of substitution is likely to be relatively large. Fornaro et al. (2025) calibrate their model under the assumption that it is equal to 2, a choice which implies responses of inflation and GDP to a green regulation shock of the same order of magnitude as those estimated by Känzig (2023). Lower values of this elasticity would amplify the drop in output and productivity.

Investment in green innovation, on the other hand, can ease the trade-off and allow for a less costly transition. Even under the assumption that productivity will not change in the steady state, investment in green technology will mitigate the productivity losses of the reallocation effect outlined here. To the extent that investment and its allocation depend on monetary policy, however, central banks may find that an excessive focus on inflation stabilisation can have costs in terms of productivity and investment allocation. We turn to the discussion of this point in the next section.

## 2 IMPLICATIONS FOR MONETARY POLICY

Tighter regulation on the use of dirty inputs, in principle, shortens the horizon of investment in dirty technologies and creates incentives to increase investment in clean technologies. Intuitively, firms in the dirty sector anticipate that they will be severely constrained by green regulations in the future, which leads to a sharp drop in dirty investments. The opposite happens to firms producing clean goods, which are instead likely to ramp investments up in response to tighter green regulations.

Fornaro et al. (2025) study the impact of the green transition in a macroeconomic model with nominal wage rigidity and investment. They calibrate their model so that green regulations do not permanently affect productivity growth in the steady state, which is the baseline case considered by Pisani-Ferry and Mahfouz (2023). This means that green technologies are productive enough so that the phasing out of dirty technologies does not affect long-run growth, but they are not sufficiently productive to fully compensate for the productivity losses experienced by the economy during the transition.

Based on this calibration, the effect of tighter limits on carbon emissions on the reallocation of investment towards clean technologies will depend on the cost of capital and aggregate demand.

A monetary contraction aimed at stabilising inflation will have a negative effect on total investment because changes in aggregate demand have an impact on the how profitable it is for firms to build up their productive capacity. Moreover, this effect will be stronger for green investment since, due to the progressive tightening of green regulations, firms producing dirty goods have a short time horizon and, as a consequence, their investment decisions are not that sensitive to changes in interest rates.

Therefore, we should expect green investment to be particularly sensitive to financial conditions and aggregate demand. The higher sensitivity of green investment to financial conditions is consistent with econometric evidence from Fornaro et al. (2025) who study a sample of US public companies (Box 1).

### BOX 1 THE EFFECT OF TIGHTENING OF FINANCIAL CONDITIONS ON GREEN INVESTMENT AND RESEARCH AND DEVELOPMENT

The study by Fornaro et al. (2025) focuses on US public companies. Data on investment and R&D activity available from Compustat from 1976 to 2023 are matched with patent data available from the US patent and Trademark Office (USPTO). Through the matching, three groups of companies are identified: non-innovators (zero cumulative patents applications over the sample), non-green innovators (less than 25% green patents applications cumulatively) and green innovators (cumulative green patent applications greater than 25%).

This classification scheme results in a group of around 50 green innovators on average. These are companies operating in the clean technology, renewable energy, and advanced materials fields, with a strong focus on solar energy, alternative fuels, and energy storage. Although many green patents are filed by the larger group of generic innovators, the selected green-focused group is interesting because is specialised in green innovation and does almost no non-green patenting.

This group has a higher average exposure to risk, as measured by asset beta, than the other two groups. A high asset beta indicates that the company's underlying business (before considering leverage) is highly sensitive to macroeconomic or market conditions. Asset beta strips out the effect of the capital structure and therefore reflects the true business risk of these companies. Since research and development (R&D) is a risky form of investment, it is natural that innovators are characterised by high asset betas.

The next step is to test formally whether an increase in the tightness of financial conditions affects investment and R&D differentially across the groups. To this end, a stratified local projection of the following form is defined:

$$Y_{i,t+h} = \mu_{i,h} + \lambda_{t,h} + \sum_{g=1}^G \beta_{g,h} \cdot \mathbb{1}[Green_i \in g] \cdot FC_t + \sum_{l=1}^p \Phi_{h,l} \cdot Y_{i,t-l} + \sum_{g=1}^G \gamma'_{g,h} \cdot \mathbb{1}[Green_i \in g] \cdot r_t + \sum_{l=1}^p \sum_{g=1}^G \delta'_{g,h,l} \cdot \mathbb{1}[Green_i \in g] \cdot w_{t-l} + \xi_{i,t+h}$$

where  $i$  denotes the firm,  $h$  the horizon,  $Y_{i,t+h}$  is the dependent variable defined as either investment or R&D expenditure,  $\mu_{ih}$  and  $\lambda_{ih}$  are, respectively, firm  $i$ 's fixed effect at horizon  $h$  and the time fixed effect,  $FC_t$  is an index of financial conditions,  $r_t$  is a vector including the year-on-year growth rate of GDP and the one-year interest rate on treasury securities, while  $w_t$  collects lagged controls.  $\mathbb{1} \times Green_i \in g$  is an indicator for firm  $i$  belonging to group  $g$ , and the three groups correspond to the classification non-innovators, green innovators, and non-green innovators, as defined above.

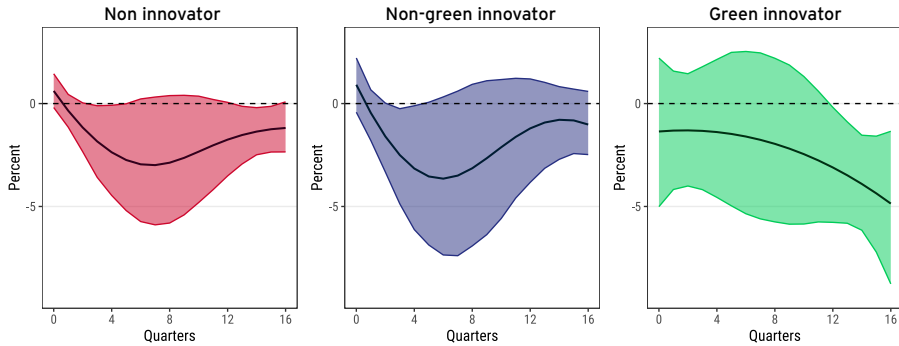
The measure of financial tightness is the Chicago's Fed Index of Financial Conditions (NFCI), which summarises broad aspects of financial tightness that might be relevant for financing R&D and investment. The index is composed of 105 indicators of financial conditions in money, debt, and equity markets and the shadow banking system. A positive value of the index indicates tighter financial conditions as measured by increasing risk, tighter credit conditions, and declining leverage, while negative values indicate the opposite.

Real investment is defined as nominal capital expenditure divided by the gross value-added deflator, while R&D expenditure is nominal expenditure on R&D divided by the gross value-added deflator.

### BOX 1 (CONTD.)

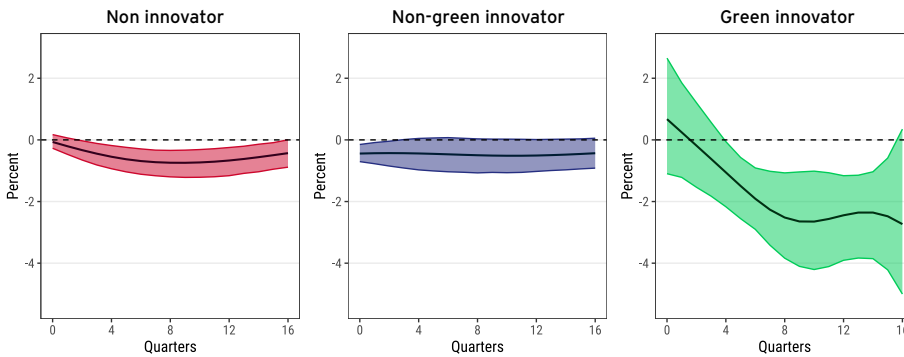
The figures below report results of the effect of a one standard deviation increase in the tightness of financial conditions on investment and R&D expenditure (for a discussion on identification and other details, see Fornaro et al., 2025). The shaded areas correspond to the 95% confidence intervals constructed using the wild cluster bootstrap method and smoothed through ridge penalization.

**Figure 2** Effect of a one standard deviation increase in tightness of financial conditions on investment, by groups of companies



Source: Fornaro et al. (2025).

**Figure 3** Effect of a one standard deviation increase in tightness of financial conditions on R&D expenditure, by groups of companies



Source: Fornaro et al. (2025).

As expected, a tightening of financial conditions is associated with a drop in investment for all groups, a result which is in line with the existing literature (Ma and Zimmerman, 2023). Moreover, consistent with the authors' conjecture, the response of the green innovators is stronger. The authors also find that tighter access to finance has a particularly strong depressive impact on R&D spending by green innovators, while it does not affect the other groups significantly. The empirical results thus accord well with those found by Aghion et al. (2024) using data on the German automotive sector.

Source: Fornaro et al. (2025).

The effect on investment and its reallocation across green and dirty technologies creates an additional trade-off for central banks. A narrow focus on maintaining inflation at target in the short term may discourage green investments and impair productivity over a longer horizon, which is likely to imply higher inflation later.

Central banks are therefore likely to face a green dilemma. On the one hand, they may choose to look through the inflationary pressures associated with the phasing out of polluting technologies. This, however, will come at the risk of a de-anchoring of inflation expectations. The other option is to combat inflation by tightening monetary policy. But this will cause a drop in economic activity, a slowdown in the rise in the relative price of dirty inputs (and thus in the rebalancing towards clean ones), as well as a reallocation of investment at the expense of green technologies.

The green dilemma that we have described applies whether or not central banks have a mandate to help the climate transition. It is the consequence of the nature of the reallocation that the economy has to go through, and of the resulting changes in relative prices. Given the costly trade-off that it faces, a monetary authority may consider adopting a more flexible approach to inflation targeting – for example, allowing for a temporary overshoot of its inflation target. Since the transition will span decades, this would imply adjusting the target upwards on the grounds that a higher target would facilitate necessary changes in relative prices. Absent this revision of the price stability target, fiscal policy would have to be mobilised so that targeted fiscal instruments could be implemented to support green investment during the tightening of monetary policy. Another option would be to use targeted balance sheet instruments supporting green credit to be used as compensation for the negative reallocation effect of a monetary contraction on green investments.

In other words, monetary policy should be complemented by targeted fiscal subsidies that lower the cost of capital, such as with the Inflation Reduction Act introduced in 2022 in the United States. Subsidising green investments helps reconcile the green transition with low inflation and high economic activity.

### **3 DEMAND, SUPPLY, AND THE EFFECT ON THE EQUILIBRIUM REAL INTEREST RATE**

Because replacing capital with fossil fuels requires a significant initial investment, the green transition affects the equilibrium (or ‘natural’) interest rate. The magnitude of its impact, however, is uncertain. On the one hand, a rise in green investment changes the aggregate saving–investment balance, pushing interest rates up. On the other hand, as already argued, replacing dirty technologies with clean ones is bound to lead to temporary productivity losses, pushing interest rates down.

As long as households form correct expectations and internalise the negative impact of lower productivity on their long-run income, this should push demand and interest rates down, potentially cancelling out the impact of the rise in investment. However, the strength of this effect depends on households' ability to forecast the far-distant future, which may be more limited than assumed in standard models (on this point, see Ferrari and Nispi Landi, 2024). Moreover, this effect is muted if households are constrained in their access to credit. These observations imply that forecasting the impact of the green transition on the equilibrium interest rate is subject to significant uncertainty.

In addition, the impact of different green policies on the natural interest rate is likely to be time-varying. Take fiscal subsidies for green investments as an example. In the short run, these subsidies will push up demand for investment goods, leading to a higher equilibrium interest rate. In the long run, however, higher green investment will translate into increased productive capacity of the economy. Higher productivity, in turn, will be associated with lower inflationary pressures and a lower equilibrium interest rate.

#### 4 IMPLICATIONS FOR DEVELOPING AND EMERGING COUNTRIES

While, in a developed country, the average cost of capital is mostly determined by the global saving–investment balance (and hence the equilibrium interest rate) and the monetary policy stance, in less developed economies a host of other factors enter into play. Reliance on foreign savings inflows implies risk premia that can lead the cost of capital to exceed the equilibrium interest rate by a wide margin. This especially applies to countries that are net importers of foreign capital. In this case, additional measures are needed to speed-up the transition and to improve the trade-off between inflation and economic activity during the transition.

Table 1 presents stylised facts regarding the relationship between level of development, the capital/output ratio, the carbon intensity of GDP, and the cost of capital. The first stylised fact is that the capital/output ratio increases with income per capita (or, to put it differently, development is based on capital accumulation). The second is that the relationship between the carbon intensity of GDP and income per capita is bell-shaped: carbon intensity is higher in middle-income countries than in poor countries (because they barely have capital) or advanced countries (where the capital stock is greener). The third stylised fact is that, as documented in Chapter 1 by Heather Grabbe, Jean Pisani-Ferry, Simone Tagliapietra, and Guntram Wolf, the cost of capital is a decreasing function of income per capita, but there is considerable variation across countries of similar development level.

TABLE 1 STYLISED FACTS ON CARBON INTENSITY AND THE COST OF CAPITAL

	Low-income countries	Middle-income countries	High-income countries
Capital/output ratio	Low	Intermediate	High
Carbon intensity of GDP	Generally low	High	Generally low
Cost of capital	High	High or intermediate	Low

Middle-income countries, especially large emerging ones, are characterised by a high carbon intensity of GDP, largely because their current capital stock heavily relies on carbon-intensive technologies (see Chapter 11 by Partha Sen in this volume). They face a particularly acute dilemma because they must keep on investing to reach their development goals while at the same time modifying the composition of their investment to make it greener, and also prematurely discard part of their current capital stock because of its high carbon footprint (Bhattacharya et al. 2024). Moreover, as mentioned in Chapter 1, they often face a prohibitively high cost of capital.

In addition, reallocation costs are generally higher in less developed economies as the depth, sophistication, and liquidity of the market for equity and quasi-equity are also functions of the development level. Greater reliance on internal funds or bank finance hampers capital reallocation between companies and across sectors.

These features make decarbonisation particularly difficult for middle-income countries. The need to industrialise while replacing part of their capital stock and investing in capital-intensive green technologies raises major difficulties as these processes require mobilising scarce savings. For this reason, middle-income countries frequently face an acute trade-off between growth and the transition away from dependency on fossil fuels. If this trade-off is alleviated by better access to foreign capital, these countries may be able to adopt *ab initio* state-of-the-art green technologies. There are, however, many impediments to their transformation.

Mature economies also face decarbonisation costs, but in comparison with middle-income countries these countries are much more advanced in their transition towards a carbon-free economy. Investment requirements are still significant due to the basic mechanism indicated above, but they are on average half as much, as a proportion of GDP, as the requirements for middle-income countries.

Provided development assistance helps them to reduce the cost of capital, low-income countries, by contrast, have the opportunity to leapfrog brown industrialisation and the construction of an electricity grid to get access to distributed green electricity (see Chapter 12 in this volume by Vera Songwe).

To assess the macroeconomic implications of this transformation and their different features across countries, one needs a different framework that explicitly acknowledges that the transition entails major, and generally uneven, investments. The framework adopted by Pisani-Ferry and Mahfouz (2023) starts from a quantitative assessment of the investment requirements. Typical additional investment requirements are around 2-3% of GDP for advanced countries and twice that level for large emerging countries such as South Africa, India, Indonesia, and Nigeria. Table 2, based on Bolton and Kleinnijenhuis (2024), shows investment requirements for these four countries for the power sector only. Bearing in mind that in emerging countries, emissions from the power sector account for around 40% of total emissions, it is apparent that the investment cost of the transition as a share of GDP is much higher in these economies.

**TABLE 2 INVESTMENT REQUIREMENTS IN THE POWER SECTOR, SELECTED COUNTRIES**

	Investment requirements as a percentage of GDP
South Africa	5.6
India	3.1
Indonesia	2.5
Nigeria	2.2

Note: Investment needs are calculated assuming carbon neutrality is achieved by 2050.

Source: Own calculations based on Bolton and Kleinnijenhuis (2024).

In addition, as developed in Chapter 1, the cost of capital is also twice as high for these economies than for advanced countries due to country-specific risks and macroeconomic factors. This implies that the transition to net zero will be costly – possibly costly enough to derail decarbonisation in the absence of significant external financial support.

## 5 POLICY IMPLICATIONS

Our analysis highlights that the green transition may push economies into a regime of high and volatile inflation, in which central banks face a particularly harsh trade-off between containing inflation and sustaining economic activity. In this regime, a temporary rise in inflation is the natural symptom of the adjustment in relative prices needed to reallocate production and investment away from dirty towards clean technologies. Finding the right assignment of monetary, fiscal, and energy policies will be particularly important to achieve the transition while minimising its output costs and keeping inflation under control.

In particular, fiscal and credit policies that subsidise green investment may be key to reconcile low inflation and high economic activity with an effective green transition. There is evidence (see Box 1) that tighter financial conditions have a particularly negative effect on green investments. Controlling inflation through a tight monetary policy stance is therefore bound to penalise green investment and hamper the transition. Fiscal and credit policies sustaining green investment can counteract this effect. There are many options that can be considered. If we abstract from considerations on the nature of the mandate of different central banks and the legal constraints, a case can be made for the use of a combination of interest rate policy and non-neutral balance sheet policies targeting the green sector. When the economy is undergoing structural transformation, non-neutral policy of this kind may actually be coherent with a medium-term inflation objective. Conversely, neutral monetary policy may have non-neutral effects, which will end up being inflationary in the long term.

Interestingly, targeted balance sheet policies by central banks – in the form of collateral policy, targeted loans or asset purchases – have been actively used by many central banks, as discussed in a recent report by the Network for Greening the Financial System (NGFS, 2024). For example, central banks in the Asia Pacific region, including the Bank of Japan, the People’s Bank of China, and Bank Negara Malaysia, have introduced refinancing operations targeting green projects to support the shift towards a lower-carbon economy.

Such targeting of monetary policy is common in developing and emerging economies, but more seldom practiced in Western advanced economies where central banks’ stance on climate policy ranges from neutrality (in the case for the Federal Reserve, even before the Trump administration) to a particular attention to the financial stability consequences of transition risks (in the case of the ECB, the Bank of England, and others). The ECB, for example, has committed to restricting the use of assets issued by entities with a high carbon footprint as collateral, with the aim of limiting its own exposure to climate risks. Similarly, the Hong Kong Monetary Authority plans to incorporate sustainability considerations into its evaluation of eligible collateral.

However, the rationale for the policies we have discussed in Section 2 is not climate-related financial risk, but rather the choice of a policy mix that encourages the green transition. As argued in Section 2, central banks face a dilemma between their price stability objective and the need to facilitate the green transition. The latter objective, however, can be pursued without the central bank departing from its price stability mandate with a combination of carbon pricing and fiscal subsidies. The choice of the right policy approach depends on the mandate of the central bank and the fiscal space enjoyed by the national government.

Emerging and developing countries can often rely on the allocative role of the central bank and therefore do not face the same dilemma. But due to competing investment needs and the high cost of capital, they face an acute trade-off between development and the transition away from fossil fuels. Investment needs cannot be diminished, but policy

can help reduce the cost of capital. This requires both action on the domestic front to ensure better policy credibility and transparency, and action at the international level to help improve access to foreign capital, including through the multilateral development banks.

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## CHAPTER 3

63

# The Paris Agreement: Successes, shortcomings, and reform options

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When the Paris Agreement was negotiated, the French presidency had in mind the previous failures of global climate governance, especially at COP15 in Copenhagen in 2009. That summit saw the clash of sovereignties between the United States and China, and between the BASIC group (Brazil, South Africa, India, and China) and the G7 countries more generally. Copenhagen ended in failure to agree a global deal for climate action. The COP21 presidency drew the conclusion that, to be a success, the Paris Agreement had to go above and beyond a mere agreement among nation-states. It was already convinced back then that, both to broker the deal and then to make it truly transformational, the Paris Agreement would need to mobilise other parts of societies, beyond nation-states: from businesses to investors, cities to local authorities, and organised civil society more broadly.

The Paris Agreement is built on four pillars. The first is the legal framework of the Agreement itself (the set of goals, incentives, rules and norms, included in the Paris Agreement). The second are the ten-year climate and growth plans that all countries must prepare and submit, every five years: the Nationally Determined Contributions (NDCs). The third is finance: both the provision of climate finance and the alignment of all financial flows with the objectives of the Paris Agreement. And the fourth are the commitments and actions by non-state actors: cities and local authorities, businesses and investors, etc. It is by looking at the progress made, for the past ten years, along each of these four dimensions that one can get a full picture of the effects of the Paris Agreement.

<sup>1</sup> Acknowledgement for the help of Daniel Wraith, ECF Advisor and Speechwriter to the CEO, and Cecilia Trasi, Research Analyst at Bruegel.

## THE FOUNDATIONAL CONCEPTS BEHIND THE PARIS AGREEMENT

As well as the experience of previous failed attempts to reach a global deal on climate, the Paris Agreement drew on several useful concepts in the theory of international relations and global governance.

### Bottom-up and top-down approaches

The Paris Agreement is often described as a bottom-up agreement. This is only partly true. Compared to previous agreements, and particularly the Kyoto Protocol – which was not a global deal, but an agreement covering only the rich countries' emissions (minus the United States, which never ratified the protocol) – the Paris Agreement is a more bottom-up type of agreement. It does not allocate national contributions to the global emissions reduction target using an explicit allocation formula. Rather, it recognises and relies on national sovereignty, through the central concept of NDCs, to achieve the global goals for climate action.

But the Paris Agreement is not just a bottom-up agreement. It also includes key elements that are more top down in nature. The global goal of the Paris Agreement of achieving net-zero emissions around mid-century – aimed at keeping global temperature rise to well below 2°C and preferably to 1.5°C above pre-industrial levels – is a science-based benchmark and is clearly one such example. Long-term, zero-emissions growth strategies are another, as well as the 'ratchet mechanism'. Since the adoption of the Paris Agreement, 107 countries – collectively responsible for approximately 82% of global greenhouse gas (GHG) emissions and including all G20 members – have committed to net-zero targets in various forms, such as in national laws, in national climate action plans, long-term strategies, or official high-level announcements (UNEP, 2024a).

### Regime complex

A key concept informing the Paris Agreement is the notion of a 'regime complex', in contrast to a centralised system of global climate governance based solely on a single institution or process such as the Conferences of the Parties (COPs). While the COPs and the Paris Agreement serve as central nodes, they are part of a broader network of institutions and processes that play a role in global climate governance and the implementation of climate action.

Within this regime complex, the Paris Agreement fulfils four functions. First, it establishes a series of goals for global climate action, including on emissions reduction, adaptation, and the mobilisation of finance and technology in support of these objectives. Second, it provides norms and mechanisms to align national five-year, or in some cases ten-year, plans with these global goals – most notably, though the long-term climate and growth strategies by 2050 and the five-year ratchet mechanism to increase NDCs.

Third, it creates incentives for global climate action by promoting the alignment of financial flows and technologies with its overarching objectives. Fourth, it includes and mobilises non-state actors spanning from businesses, investors, cities, and sub-nationals to organised civil society such as the scientific community, NGOs, and social movements.

From the perspective of a regime complex, the effectiveness of global climate governance hinges on two factors: the strength and clarity of the signal sent by the Paris Agreement as the central node of the global climate regime; and the responsiveness of the other institutions in aligning their activities with its objectives. One of the clearest examples of this alignment is the recognition by an increasing number of central banks that climate change is highly relevant to their mandate.

Through the creation of the Network for Greening the Financial System (NGFS) in 2017, central banks began to integrate climate risk into their approach to micro- and macroprudential regulation and explore ways to ‘green’ their monetary policy. The NGFS developed detailed climate scenarios to assess the potential impact of climate change on the financial system and has issued guidance for supervisors on integrating climate-related and environmental risks into prudential oversight.<sup>2</sup>

For example, in 2021, the Bank of England conducted a sophisticated assessment of the financial system’s resilience to both physical and transition risks under three of these scenarios. Similarly, the European Central Bank now regularly conducts a comprehensive climate stress test across the euro area’s banking sector and has adjusted its corporate bond holdings to favour issuers aligned with the Paris Agreement (Lagarde, 2022). The NGFS currently includes 142 members from over 90 countries and 21 observers, covering 100% of global systemic banks and 80% of the internationally active insurance groups.<sup>3</sup>

Although the debate about integrating climate change into the mandates of central banks persists, the Paris Agreement has influenced the growing consensus that both physical climate risks and transition risks are relevant to financial stability. In jurisdictions such as the European Union, at least until now, stringent disclosure requirements for corporate transition plans have been introduced to ensure that financial institutions and central banks have access to data to assess these risks.

### **Multi-scale governance**

The second foundation concept of the Paris Agreement is multi-scale governance. No international agreement – regardless of its legal strength – can, on its own, resolve the global climate crisis. The effectiveness of climate action fundamentally hinges on implementation at multiple levels – through national and local government policies,

2 See the NGFS Scenarios Portal at <https://www.ngfs.net/ngfs-scenarios-portal/>

3 See the NGFS membership at <https://www.ngfs.net/en/about-us/membership>

choices of businesses and investors, and individual behavioural changes. Nation-states – even when represented as unified actors in international negotiations – are complex political economies shaped by diverse interests, constituencies, and institutional dynamics, both domestically and internationally (Keohane and Victor, 2011).

One measure of the effectiveness of the Paris Agreement is how NDCs have been translated into national laws and sector-specific policies. From this perspective, the Paris Agreement has had a strong impact, triggering a wave of climate policies across an unprecedented number of countries (Roelfsema et al., 2020). However, as discussed later, this wave has yet to meet the scale of policy change required to meet the Agreement's objectives.

Another measure of effectiveness is its function as a mobiliser of non-state actors, both above and below the national level. One illustration is its influence on cities and sub-national governments (e.g., regions and provinces). Many mayors and governors have used the Paris Agreement as a platform to affirm and strengthen their role in national politics. While these actions often serve immediate local interests (e.g., reducing air pollution, improving energy efficiency or cutting traffic congestion), they also reinforce the leadership of mayors and governors pushing for more ambitious and more effective climate action at the national level.

### **Rational expectations and animal spirits: Relying on self-fulfilling prophecy**

The fourth and final concept underpinning the Paris Agreement comes less from international relations and more from the field of communication. It concerns how expectations shape the economic behaviour of businesses and investors. Climate action is not driven solely by rational calculations based on existing policies and regulatory signals, but also by the anticipation of what lies ahead – the belief that a low-carbon transformation is not only desirable but already unfolding. This dynamic combines rational expectations – based on the trajectory of government policies – with what Keynes famously called the 'animal spirits' of market actors. This interplay between policy certainty and market psychology creates fertile ground for self-fulfilling prophecies, where belief in the transition accelerates its realisation.

This is why a communication strategy was central to the diplomatic processes leading up to and during COP21 in Paris. The French COP presidency deliberately refrained from pushing its own version of the Agreement draft, wanting to trust the Party-driven process – especially in light of the lessons learned from the diplomatic failures of COP15 in Copenhagen. However, it did have a clear communicative vision about crafting a global narrative portraying the climate transition as not just beneficial but inevitable too, because it is already well underway. The goal was to create headlines that projected

inevitability, not just ambition. By showcasing tangible actions already being taken by businesses and investors, cities and sub-national governments through the Action Agenda of the Paris Agreement, the presidency aimed to show how the climate transformation was happening already, and those who delay would be left behind.

This was the fundamental theory of change of the Paris Agreement: action begets more action, even more than words, commitments, and targets.

## CONCRETE IMPACTS

### Policy as catalyst: Accelerating deployment and bending the emissions curve since Paris

Nearly a decade after its adoption, the Paris Agreement has contributed to a measurable shift in global climate trajectories. While it is difficult to causally isolate its precise impact, the evolution of temperature projections offers insights of its catalytic effect.

In 2015, warming under current policies was projected to reach 3.6°C by 2100. By 2021, this estimate had dropped to 2.7°C – reflecting the post-Paris wave of new policies and increased ambition. Similarly, projections based on the full implementation of 2030 NDC targets and submitted long-term commitments (such as net-zero pledges) declined from 2.7°C in 2015 to 2.1°C in 2021 (Ellis et al., 2024). When factoring in countries' 2030 targets (NDCs), projected warming drops further to 2.6°C, and falls to 2.1°C when also including binding long-term targets such as net-zero pledges. These three levels – real-world policy implementation, near-term NDCs, and long-term strategies (LTSs)<sup>4</sup> – together explain a 1.5°C reduction in projected warming compared to pre-Paris trajectories. However, this early progress has stalled. Since 2021, key indicators have plateaued. The ratchet mechanism that was meant to drive accelerating ambition has yet to regain momentum following the disruption of COVID-19 (Ellis et al., 2024).

Since the Paris Agreement, the global policy landscape has undergone a decisive qualitative and quantitative shift marked by a surge in the adoption of binding and economically significant climate policies. One example is the proliferation of carbon pricing mechanisms: by 2023, more than 75 initiatives were either in operation or scheduled, covering around 24% of GHG emissions – up from just 7% in 2013.<sup>5</sup> It is difficult to conceive of this happening without the long-term signal and iterative

4 The Climate Action Tracker distinguishes between three core scenarios, each corresponding to a different level of policy ambition and implementation. The "Policies and action" scenario reflects the trajectory based on currently implemented domestic policies, excluding unlegislated targets or pledges. The "2030 targets only" scenario incorporates the implementation of countries' NDCs for 2030, including conditional elements where applicable. The "Pledges and targets" scenario builds on this by adding binding or submitted long-term targets (e.g., net-zero commitments) where sufficient detail and credibility exist. These scenarios are not forecasts, but policy-based projections that assume no additional mitigation action beyond what is stated or enacted at the time of assessment. Each level progressively narrows the emissions gap relative to the Paris Agreement's long-term temperature goals, but the divergence between them also illustrates the risk of over-relying on pledges without credible near-term action.

5 "Global Carbon Pricing Revenues Top a Record \$100 Billion", World Bank press release, 21 May 2024 (<https://www.worldbank.org/en/news/press-release/2024/05/21/global-carbon-pricing-revenues-top-a-record-100-billion>).

framework established by the Paris Agreement. By providing a durable institutional architecture and anchoring expectations around progressive decarbonisation, the Paris Agreement created the conditions for a wave of national policymaking that reshaped climate targets, investment incentives, and market behaviour. Many of the policies driving recent emissions reductions were made more politically feasible and economically viable.

These policy shifts have driven the remarkable acceleration in clean energy innovation and deployment over the past decade. Between 2015 and 2022, global solar PV capacity additions rose by over 400%, while battery storage installations increased by 2,500% (IEA, 2024b; 2024a). Deployment-weighted costs of solar, wind, batteries, and heat pumps have fallen by around 80% since 2010 (IRENA, 2024). Public spending in clean energy research and development (R&D) has grown from around US\$30 billion in 2015 to \$44 billion in 2022, with more than 80% directed at low-emission technologies. Corporate energy R&D reached over \$130 billion globally in 2022, with renewables firms increasing their R&D expenditure by 25% annually since 2020 – a sharp acceleration compared to the previous decade (IEA, 2023b). Clean technology innovation also surged, with patents in low-emission technologies rising steadily while fossil fuel patents have declined. As the IEA's analysis makes clear, these transformations were not spontaneous or due to market forces alone, but were enabled by the long-term policy signals, demand certainty, and market anticipation generated in response to the Paris Agreement.

The power sector has emerged as the single largest contributor to global emissions reductions since the Paris Agreement, with decarbonisation driven primarily by the accelerated deployment of solar PV and wind energy technologies. According to the IEA, of the 7.5 Gt in avoided energy-related CO<sub>2</sub> emissions projected for 2030 under the 2023 Stated Policies Scenario relative to the pre-Paris baseline, nearly 5 Gt can be attributed to solar (3 Gt) and wind (2 Gt) alone (IEA, 2023c). At the country level, India (1.3 Gt avoided), China (1.2 Gt), the United States (1.7 Gt), and the European Union plus the United Kingdom (0.9 Gt) are the largest contributors to the sector decarbonisation – particularly through solar and wind. In China, for instance, solar and wind are projected to account for over 33% of electricity generation in the 2023 scenario – up from under 10% in the 2015 baseline.

In the transport sector, electric vehicles (EVs) are expected to avoid approximately 1 Gt CO<sub>2</sub> globally by 2030. EV sales are projected to comprise more than one-third of global car sales by that year under the stated policies scenario – a stark contrast with negligible uptake in the baseline. Regionally, EV sales are projected to reach 50% in the United States, two-thirds in China and in the European Union plus the United Kingdom (IEA, 2023a).

The material shifts in emissions trajectories, investment flows, technology deployment, and policy frameworks reflect the Paris Agreement's undeniable influence on global climate governance. Yet, they remain insufficient. Despite progress, current policies are projected to lead to a median global warming of approximately 2.7°C by 2100 – implying

a 50% chance of higher or lower outcomes. Given uncertainties in the climate system, there is a one-in-three chance that warming could exceed 3.0°C, and a one-in-ten chance it could surpass 3.6°C. Overall, projections based on current policies place likely outcomes in a range between 2.2°C and 3.4°C (Ellis et al., 2024). These figures highlight a significant gap between the goals of the Paris Agreement and the trajectory implied by present-day action.

### **In the discourse: From incremental to systematic changes**

Before turning to how the system can be reformed to help bring about the required acceleration of emissions reductions, it is important to recognise the broader ways in which the Paris Agreement has shaped the global response to climate change. Not all of its impacts can be measured in tonnes of CO<sub>2</sub> avoided or dollars of finance mobilised. Some of the most significant shifts lie in how climate action is understood, prioritised, and organised – across diplomatic, financial, and institutional spheres. These are harder to quantify, but no less essential to long-term transformation.

Some of the Paris Agreement's most enduring impacts are not immediately visible in quantitative metrics. First, many emissions-reduction efforts take time to bear fruit, given the structural inertia of existing systems. Systems change is slow, but ultimately decisive. Second, how the problem is framed – and how solutions are institutionalised – matters as much as emissions totals or dollar figures. In this sense, the Paris Agreement marked a sharp departure from previous climate regimes, and a major step forward in at least two respects.

#### *From incremental approach to systemic change*

The first is the pivot from an incremental emissions reduction approach to a mission-oriented, systemic change approach. Before Paris, mitigation strategies primarily emphasised gradual emissions reductions. The goal was not to reach net-zero emissions (defined as reducing the balance between the gross GHG emissions from the combustion of fossil fuels, deforestation, and so on and their removal through the absorption by natural sinks like forests, mangroves and other ecosystems, or through carbon capture and storage (CCS)).

Back in Copenhagen, even the most developed countries only committed to reduce their own emissions by between 80% and 95% by 2050. Emerging economies, including India, South Africa, and Brazil, set their climate objectives either as a deviation from the business-as-usual (BAU) scenario or as a carbon intensity target (defined as the ratio between carbon emissions and GDP, as China did). In both frameworks, climate targets were set as emission growth limits, not as absolute emission reduction targets (except for Brazil).

After Paris, all G20 countries have committed to net-zero emissions targets by mid-century or later: 2060 for China and 2070 for India. This represents a major shift in long-term ambition and underscores the catalytic effect of the Agreement on national goal setting. However, a significant gap persists between countries' long-term pledges and the near-term policies and plans outlined in their NDCs, and the goal of the Paris Agreement. While projections based on 2030 NDC targets alone suggest a likely warming range of 2.1°C to 3.2°C, a broader assessment that includes both 2030 targets and binding long-term commitments – such as net-zero goals – indicates a projected temperature increase of 1.7°C to 2.7°C by 2100 (Ellis et al., 2024). Moreover, many developing countries' NDCs remain conditional on receiving international financial and technical support, further underscoring the gap between ambition and feasible implementation without adequate external backing (UNFCCC, 2024b). At the same time China's emissions already peaked earlier than committed and may decline significantly before 2035.

Beyond resource constraints, structural governance challenges limit implementation capacity. Democracies face a structural difficulty: the misalignment between short electoral cycles and the sustained policy continuity needed to deliver a long-term objective. In more centralised systems such as China, the continuity of government and integration of long-term goals into national planning processes provide some institutional advantages – but even there, implementation has struggled to keep pace with commitments.

### 1.5 degrees Celsius

Another example of epistemic change induced by the Paris Agreement has been the adoption of the 1.5°C temperature increase limit as the primary goal in global climate discourse. While the Paris Agreement formally commits countries to limit the increase in global average temperature to “well below 2 °C above pre-industrial levels” and to “pursue efforts to limit the temperature increase to 1.5 °C”<sup>6</sup>, it is the “1.5°C” that has become the reference for global climate action. Two events explain this.

The first was the publication of the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C in October 2018. Mandated by the Paris Agreement, the report explored in detail the impacts of global warming at 1.5°C above pre-industrial levels and the pathways to limit warming to that level. Its findings were shocking and highlighted that limiting warming to 1.5°C compared to 2°C would significantly reduce the risks to health, livelihoods, food security, water supply, and economic growth. The report detailed that 1.5°C of warming could lead to the loss of up to 70–90% of coral reefs, while 2°C would push that number above 99%. It also found that the number of people exposed to climate-related risks and susceptible to poverty would

6 See Paris Agreement, Article 2.1(a).

be significantly lower at 1.5°C than at 2°C (Hoegh-Guldberg et al., 2018), and highlighted the importance of staying at 1.5°C temperature increase to avoid crossing some tipping points, such as the collapse of the Amazon ecosystem. These conclusions served as a wake-up call to policymakers, civil society, and the global public.

The second event is mobilisation of the youth, notably in 2019. Sparked in part by the urgency articulated in the IPCC 1.5 Special report, youth movements like Fridays for Future used the 1.5°C goal as rallying cry. They demanded that governments and political leaders deliver on their commitments and ‘walk the talk’ of implementing the Paris Agreement. They emphasised the intergenerational injustice of inaction and some groups even brought litigation against governments and companies for their failure to act. This marks a significant evolution from pre-Paris climate activism, which focused more on achieving a binding global deal. Post-Paris, the emphasis has shifted toward ensuring the implementation of the deal and holding leaders accountable for promises made.

While setting an objective is not equivalent to achieving it and public mobilisation does not automatically lead to political action, both developments reflect the importance of a clear, science-based understanding of possible futures under different scenarios.

### **In law and litigation**

One of the less anticipated, but increasingly powerful, effects of the Paris Agreement has been its impact on legal systems. Since its adoption in 2015, courts around the world have increasingly treated the Agreement as a normative benchmark in climate litigation – shaping the responsibilities of both governments and private actors.

According to the Sabin Center for Climate Change Law at Columbia University and the Grantham Research Institute at LSE, more than 2,500 climate-related legal cases have referenced the Paris Agreement as of early 2024. These cases span over 65 jurisdictions, including national, regional, and international courts. Approximately two-thirds have been filed against public authorities, while the remaining third target private actors – most notably, corporations and financial institutions. The surge in cases against businesses is particularly recent: of the roughly 230 cases filed against companies since 2015, more than two-thirds have been brought since 2020, indicating a sharp rise in efforts to establish corporate accountability (Setzer and Higham, 2024).

Several landmark rulings have relied directly on Paris-based obligations or used the Agreement to interpret constitutional and human rights law. These include:

- *Urgenda Foundation v. State of the Netherlands* (Dutch Supreme Court, 2019): The Dutch Supreme Court upheld the government’s duty to reduce emissions, citing the Paris Agreement and human rights principles<sup>7</sup>.

7 “Urgenda Foundation v. State of the Netherlands”, Climate Case Litigation Databases, Sabin Center for Climate Change Law (<https://climatecasechart.com/non-us-case/urgenda-foundation-v-kingdom-of-the-netherlands/>).

- *Neubauer, et al. v. Germany* (2020): Declared parts of the German Climate Act unconstitutional for failing to protect future generations, explicitly referencing the Paris Agreement<sup>8</sup>.
- *KlimaSeniorinnen v Switzerland* (ECtHR) (2020): Ruled that inadequate climate action violated the rights of elderly women under the European Convention on Human Rights<sup>9</sup>.
- *Notre Affaire à Tous and Others v. France* (2020): Found the French state responsible for ecological damage due to insufficient climate measures<sup>10</sup>.

Corporations, too, have come under growing judicial scrutiny, including in high-profile cases such as:

- *Milieudefensie v. Royal Dutch Shell* (Netherlands, 2019): Ordered Shell to reduce its global carbon emissions by 45% by 2030, referencing the company's obligations under the Paris Agreement.<sup>11</sup>
- *Greenpeace Italy v. Eni* (Italy, 2023): A prominent case asserting that Eni's business practices violate Italy's Paris-aligned climate obligations.<sup>12</sup>

This growing body of case law reflects a broader trend: the judicialisation of climate governance, where courts are increasingly used as arenas for advancing or enforcing climate ambition. While enforcement powers remain uneven across jurisdictions, the Paris Agreement has emerged as a central reference point in translating global climate goals into legal duties and justiciable rights.

## THE TRADITIONAL CRITIQUES

### The Paris Agreement is toothless

One of the most common criticisms of the Paris Agreement is that it is non-binding and lacks enforcement mechanisms. This criticism ignores that there is a clear trade-off between the legally binding nature of an agreement and its depth and breadth. The higher the sanctions in case of non-compliance, the bigger the incentive to set a conservative target, to maximise the chances of reaching the target. International

8 "Neubauer, et al. v. Germany", Climate Case Litigation Databases, Sabin Center for Climate Change Law (<https://climatecasechart.com/non-us-case/neubauer-et-al-v-germany/>)

9 "KlimaSeniorinnen v Switzerland (ECtHR)", Climate Case Litigation Databases, Sabin Center for Climate Change Law (<https://climatecasechart.com/non-us-case/union-of-swiss-senior-women-for-climate-protection-v-swiss-federal-council-and-others/>).

10 "Notre Affaire à Tous and Others v. France", Climate Case Litigation Databases, Sabin Center for Climate Change Law (<https://climatecasechart.com/non-us-case/neubauer-et-al-v-germany/>).

11 "Milieudefensie et al. v. Royal Dutch Shell plc.", Climate Case Litigation Databases, Sabin Center for Climate Change Law (<https://climatecasechart.com/non-us-case/milieudefensie-et-al-v-royal-dutch-shell-plc/>).

12 "Greenpeace Italy et. Al. v. ENI S.p.A., the Italian Ministry of Economy and Finance and Cassa Depositi e Prestiti S.p.A.", Climate Case Litigation Databases, Sabin Center for Climate Change Law (<https://climatecasechart.com/non-us-case/greenpeace-italy-et-al-v-eni-spa-the-italian-ministry-of-economy-and-finance-and-cassa-depositi-e-prestiti-spa/>).

agreements including sanctions in case of non-compliance are well-suited to some types of issues, such as those that require restraint in the use of force. This is the case in the event of armed conflicts – the sanctions imposed on Russia after it violated the integrity of Ukrainian territory are a clear example.

But sanctions are ill-suited when it comes to other types of issues, where the challenge is not to prevent the use of force, or restrain action, but to bring about active transformational change and cooperation. As the IPCC highlights, in such cases, systemic changes – across energy, infrastructure, food systems, and finance – are more likely brought about by incentives and enabling conditions rather than by sanctions.

Theoretical and practical experience shows that any attempt at designing a global climate regime which includes hard sanctions in case of non-compliance – especially today, given the balance of geopolitical power – will inevitably result in less, not more, global climate action (Raustiala, 2005). In fact, attempts to introduce ‘hard law’ in global climate agreements (e.g., the Kyoto Protocol) led to limited participation and even withdrawal by key actors. The Paris Agreement, in contrast, by relying on NDCs and iterative transparency mechanisms, maximises participation and fosters a norm of progressive ambition.

### **The Paris Agreement limits national sovereignty**

Another frequent criticism of the Paris Agreement is that, like the entire concept of global governance, it infringes national sovereignty. This is the core of US President Donald Trump’s rejection of the Agreement,<sup>13</sup> which he framed as an infringement on American autonomy and prosperity. Similar arguments have been echoed by former Brazilian President Jair Bolsonaro, who rejected international scrutiny of the Amazon as a violation of Brazil’s sovereign right to pursue its own development path.<sup>14</sup> These critiques are largely political rather than legal in nature, but they reflect an enduring tension between international cooperation and the perception of domestic control.

This critique is misplaced. The climate crisis is inherently global: emissions released in one country affect communities and ecosystems everywhere, and no nation can secure a resilient, low-emissions future without international cooperation. In this context, sovereignty cannot simply mean freedom from external constraint. It must also mean the capacity of states and societies to achieve the goals their citizens set for themselves – including security, prosperity, and environmental stability. Climate impacts, left unmanaged, directly undermine that capacity.

13 “Statement by President Trump on the Paris Climate Accord”, 1 June 2017 (<https://trumpwhitehouse.archives.gov/briefings-statements/statement-president-trump-paris-climate-accord/>).

14 “Speech by Brazil’s President Jair Bolsonaro at the opening of the 74th United Nations General Assembly - New York, September 24, 2019” (<https://www.gov.br/mre/en/content-centers/speeches-articles-and-interviews/president-of-the-federative-republic-of-brazil/speeches/speech-by-brazil-s-president-jair-bolsonaro-at-the-opening-of-the-74th-United-Nations-General-Assembly-New-York-September-24-2019-photo-alan-santos-pr>).

Far from eroding sovereignty, global climate governance reinforces it by enabling governments to protect their populations and plan for long-term wellbeing. The Paris Agreement does not impose top-down obligations; rather, it respects sovereignty by allowing each country to define its own path through NDCs. It functions as a ‘pledge and review’ system, aiming to balance flexibility with accountability. The Paris Agreement respects national decision making while creating the framework through which collective action becomes possible.

### **1.5°C is already dead**

A narrative gaining traction suggests that the Paris Agreement is losing its relevance because the objective of limiting global temperature rise to 1.5°C is no longer attainable. This misconstrues both the structure and ongoing function of the Agreement.

First, while it is increasingly likely that the 1.5°C threshold will be exceeded (UNFCCC, 2024b), Article 2.1 of the Paris Agreement commits countries to hold global warming well below 2°C while pursuing efforts to limit it to 1.5°C.

Second, scientific evidence makes clear that the climate system does not respond to hard temperature cut-offs, but to cumulative emissions (IPCC, 2023). Overshooting 1.5°C temporarily does not mean irreversible catastrophe is inevitable. As the IPCC emphasises, every tenth of a degree avoided still reduces the risk of irreversible harm and improves the odds of managing the transition in a just and orderly way.

Third, the Paris Agreement is a living instrument and remains the central framework for international cooperation on climate. It includes mechanisms for updating NDCs every five years, ensuring that ambition can ramp up in response to new science and political momentum. The framework remains central not only for mitigation but also for climate finance, adaptation, and resilience.

## **THE PARIS AGREEMENT PUT INTO PERSPECTIVE: TWO OTHER OPTIONS**

It is worth considering alternative proposals – typically grounded in explicit or implicit critiques of the Paris model – and assess whether they offer viable complements or correctives to the current framework.

### **Carbon club**

Nobel laureate economist William Nordhaus (2015), for instance, argues that voluntary international climate agreements are structurally prone to free-riding and ultimately ineffective without credible enforcement mechanisms. His reasoning draws on classical game theory: when the provision of collective goods (like a stable climate) requires costly national actions, rational actors may choose to defect unless compelled by external

incentives. In the context of global climate governance, while the benefits of emissions reductions are shared globally, the costs are borne nationally, creating strong incentives for countries to free ride. Without sanctions or economic penalties, even the most ambitious actors risk being undercut by less committed competitors.

Nordhaus's proposed alternative is the creation of a climate club: a coalition of countries that commit to a shared minimum carbon price and impose trade penalties on non-members. The core idea is simple. Members of the club adopt a baseline carbon price – for example, \$50 per tonne – and agree to apply border tariffs (say 5–10%) on imports from countries that do not meet this threshold. These dual conditions – a common internal standard and a penalty for outsiders – create a self-reinforcing incentive to join. According to Nordhaus's modelling, such a structure could yield a more stable and effective coalition than voluntary multilateralism.

The value of the climate club proposal lies in its conceptual clarity. It explicitly confronts the problem of non-compliance and proposes a mechanism to make cooperation economically rational. In theoretical terms, it offers a 'first-best' solution – a stylised optimum from the perspective of economic efficiency and incentive design. It also highlights an important threshold insight: beyond a certain level of decarbonisation, some form of protective trade policy may become necessary to maintain ambition and avoid carbon leakage.

However, the club model faces significant practical and political barriers. Carbon pricing – particularly through explicit taxes or trading schemes – represents only a fraction of the actual climate policy mix in most countries. Much of the heavy lifting is done through regulation, subsidies, and industrial policy. Calculating a comparable 'implicit' carbon price across jurisdictions is both technically complex and politically contentious, as shown by debates surrounding the EU's Carbon Border Adjustment Mechanism (CBAM). The feasibility of agreeing on a baseline price – let alone enforcing it globally – remains remote.

Moreover, Nordhaus's model assumes that non-members would accept trade penalties without retaliation. In today's context of escalating geopolitical fragmentation and trade tensions – including with the United States – that assumption appears increasingly fragile. The model underestimates the political risks of backlash and escalation.

Ultimately, Nordhaus's carbon club is better understood as a thought experiment than a ready-to-implement blueprint. Its usefulness lies in sharpening the focus on incentives, enforcement, and fairness – elements the Paris Agreement has deliberately downplayed in favour of flexibility and universality. The logic of clubs may yet inform the evolution of climate governance, particularly in areas like trade and investment. But as a replacement for the Paris framework, it remains politically implausible and normatively incomplete.

## Sectoral agreements

An alternative approach focuses on narrowing the scope of action to specific key economic sectors. Inspired in part by the Montreal Protocol on Substances that Deplete the Ozone Layer, proponents of such an approach typically advocate agreements tailored to the unique characteristics of hard-to-abase sector – such as technological readiness, actor concentration, and market structure – rather than imposing universal, economy-wide frameworks (Bodansky, 2017).

Yet, to be effective they need enforcement mechanisms or accountability provisions, else, when voluntary, these efforts have generally failed to go beyond what firms were already prepared to do.<sup>15</sup> Attempts to agree a multilateral approach to tackling methane emissions are a recent pertinent example. The Global Methane Pledge, a voluntary initiative launched at COP26, aims to reduce global methane emissions by 30% by 2030 and has attracted over 150 country signatories. However, for lack of enforcement provisions, a number of signatories have failed to take the necessary action, and methane emissions from fossil fuel operations remain stubbornly high (exceeding 120 million tonnes in 2024) with little overall decline in recent years (IEA, 2025). It is time to build a more formal framework, like a protocol within the Paris Agreement, to tackle these particularly toxic emissions.

Though it is not a credible alternative to the Paris Agreement framework, this approach may nonetheless serve as a useful – if imperfect – complement in certain sectors. International shipping, for instance, is not directly included in countries' NDCs, due to the complexity of attributing emissions across jurisdictions. Instead, responsibility for this sector has been delegated to the International Maritime Organization (IMO). In April 2025, the IMO approved draft regulations to establish a legally binding framework for achieving net-zero emissions from international shipping by or around 2050.<sup>16</sup> While the framework remains modest in ambition and lacks implementation detail, it marks a significant step towards applying binding rules to an excluded but high-emitting sector, and could, if successfully adopted and enforced, help operationalise the objectives of the Paris Agreement.

## WHAT NOW? THE NEW CONTEXT AND OBJECTIVES FOR GLOBAL CLIMATE GOVERNANCE

Defenders of multilateral climate action must recognise that the global climate governance landscape in 2025 is vastly different from that of 2015.

15 "Policy Watch: COP29 comes up short on spurring reduction in industrial emissions", Reuters, 10 December 2024 (<https://www.reuters.com/sustainability/climate-energy/policy-watch-cop29-comes-up-short-spurring-reduction-industrial-emissions-2024-12-10/>).

16 "IMO approves net-zero regulations for global shipping", press release, 11 April 2025 (<https://www.imo.org/en/MediaCentre/PressBriefings/pages/IMO-approves-netzero-regulations.aspx>).

The current context for global climate governance is far removed from the conditions that enabled the Paris Agreement. The cooperative spirit that characterised the mid-2010s has significantly eroded. Political backsliding, rising geopolitical tension, and growing resistance to multilateralism – most notably with the return of Donald Trump to the US presidency – have eroded the basis for global consensus. While unpredictable in its tactics, the current US administration is consistent in its hostility to international institutions and climate action. In his first day in office, the President announced his intention to withdraw, again, from the Paris Agreement and from “any agreement, pact, accord, or similar commitment made under the United Nations Framework Convention on Climate Change”.<sup>17</sup>

The hostility extends to the domestic policies and institutions as well. Federal policies are not only halting the US green transition but actively reversing it. The current energy agenda – encapsulated by the “drill, baby, drill” slogan – prioritises expanded fossil fuel production, while simultaneously targeting renewable energy, electric vehicles, and other pillars of decarbonisation.<sup>18</sup> These actions are accompanied by a systematic undermining of scientific institutions and climate expertise (Witze et al., 2025).

This raises a fundamental question: what forms of global climate governance are feasible in the absence of US engagement? Climate action cannot wait the reconstitution of a stable global order. In the near term, plurilateral approaches – coalitions of the willing – are likely to offer the most viable path forward, particularly among countries with the fiscal space, technological capacity, and geopolitical power. These ‘climate clubs’ can coordinate action on carbon pricing, border adjustments, clean technology standards, and financial flows, setting ambitious benchmarks that others can follow (Hovi et al., 2016).

But even in the absence of geopolitical disruption, the need for systemic reform is clear. Nearly a decade after Paris, the gap between pledged targets and real-world outcomes is widening. Countries across the political spectrum are struggling to turn long-term goals into short-term delivery. As the first Global Stocktake made clear, the world is not on track to meet the goals of the Paris Agreement – nor to unlock the scale of investment and institutional alignment required to do so (UNFCCC, 2024a). While the focus in 2015 was on reaching a universal, partially binding agreement, the priority today is implementation: accelerating mitigation, adaptation, and resilience-building in line with agreed targets.

17 “Putting America First in International Environmental Agreements”, The White House, 20 January 2025 (<https://www.whitehouse.gov/presidential-actions/2025/01/putting-america-first-in-international-environmental-agreements/>).

18 “President Trump is Unleashing American Energy”, The White House, 4 March 2025 (<https://www.whitehouse.gov/articles/2025/03/president-trump-is-unleashing-american-energy/>).

Barriers to implementation remain formidable. In many countries, climate policy is caught in polarised domestic debates or seen as a political liability. Infrastructure systems, regulatory environments, and fiscal frameworks are often misaligned with climate objectives. At the international level, institutional silos persist between climate goals and the regimes governing trade, finance, and investment. These structural gaps are compounded by a credibility crisis: delays, reversals, and disputes have made it harder for both public and private actors to plan confidently around decarbonisation. According to IPCC Working Group II, these governance challenges directly constrain effective climate adaptation and threaten climate-resilient development, especially in vulnerable regions (IPCC, 2023).

Despite the deterioration of international politics and the persistence of delivery shortfalls, the Paris Agreement remains the foundation of global climate governance. In today's fragmented context, the Paris Agreement – with its clear objectives, rules, and normative framework – is more vital than ever. Its goals of emissions reduction, realignment of financial flows, resilience-building, and guidance for technological innovation continue to serve as critical anchors. The clarity and direction it provides are particularly valuable in an otherwise disordered global system.

But to deliver on its promise in challenging times, it will require reform – not to replace the existing regime, but to make it more capable of withstanding pressure and driving change. On the international scale, this involves delivering the resources and instruments necessary for real-world decarbonisation – including climate finance, technology transfer, and policy frameworks that accelerate green transitions. Then, it requires grappling with the cultural and political conflicts playing out within countries – the growing polarisation around climate, and the proliferation of disinformation. Finally, institutional linkages will need to be reformed, integrating climate objectives into trade, investment, and development policy to enable synergistic action. As emphasised in the IPCC's Sixth Assessment Report (AR6), this demands not only technological and infrastructural shifts but also transformations in governance, societal values, and economic structures.

### **Reform: Gearing the system towards implementation**

Since the adoption of the Paris Rulebook in 2018, global climate diplomacy has shifted – at least rhetorically – from negotiation to action. Some institutional progress has followed: the creation of the Loss and Damage Fund at COP27, and investment initiatives launched at COP28, particularly in renewable energy deployment in the Global South. But these remain exceptions. The overall pace of progress is too slow.

One reason is institutional design: the COP process was not designed for implementation. Instead, COPs have an agenda-setting mandate: they surface issues, broker agreements, and monitor follow-up. That role is necessary, but it is not sufficient. Driving implementation requires institutions with operational mandates – the ability to direct finance, coordinate infrastructure deployment, and support project pipelines. This is the model that already exists in fields such as humanitarian assistance and global health (e.g., the Global Fund), but it is still underdeveloped in climate governance.

The current system of global climate governance addresses implementation through three complementary channels.

The first is formal means of implementation. These include finance, technology transfer, and capacity-building – negotiated under the framework of the COPs. These instruments are intended to support the delivery of national climate plans, particularly in developing countries. However, the volume and accessibility of this support remain limited relative to the scale of the transformation required. For instance, climate finance remains insufficient. The \$100 billion per year pledge made in 2009 to support developing countries was only met in 2023, with \$115.9 billion delivered, and much of this in the form of loans, not grants (OECD, 2024). The IPCC AR6 stresses that current financial flows are three to six times lower than levels needed by 2030 to limit warming to below 2°C, and up to ten times lower for 1.5°C-compatible pathways (IPCC, 2023).

The second channel is the mobilisation of non-state actors. These include cities and local authorities, businesses, and investors. This mobilisation was a defining feature of the Paris Agreement's fourth pillar and remains a significant vector for implementation. Notably, platforms like Race to Zero and the Science Based Targets initiative (SBTi) have driven meaningful voluntary commitments, but these often lack accountability mechanisms and standardised reporting. With relatively modest institutional reform, this energy could be more effectively harnessed to deliver tangible contributions toward Paris-aligned outcomes.

The third channel is the Nationally Determined Contributions. These are the principal planning tools through which countries outline their emission reduction, adaptation, and resilience strategies, along with the means of financing them. The flexibility of the NDC framework reflects the Paris Agreement's core principle of national sovereignty: each country determines its own approach to implementation. As such, the NDCs function not only as international commitments, but as integrated national development and climate plans. However, their effectiveness depends on alignment with domestic development strategies and credible delivery mechanisms.

Pivoting global climate governance from a focus on target-setting to a focus on implementation requires action across all three of these levers: increasing resources, strengthening institutional capacity, and sharpening incentives. Without such reforms, even the most well-crafted agreements will remain symbolic rather than transformative.

## **Finance: From compatibility to direction**

The Paris Agreement fundamentally transformed the international climate finance landscape. It created a framework for articulating investment needs and mobilising support, and a shared reference point for aligning capital flows. It spurred the establishment of new initiatives and financial partnerships. National and multilateral institutions have responded with new taxonomies, disclosure rules, and risk frameworks. Regulators and central banks have begun to incorporate climate-related risks into their supervision mandates, and the private sector is more engaged than ever before.

Finance has become the central fault line in climate diplomacy, as seen in the fraught and ultimately unresolved negotiations around the ‘new collective quantified goal’ (NCQG) at COP29 – negotiations that are set to continue at COP30. The Baku to Belém Roadmap, developed in the lead-up to COP30, aims to mobilise at least \$1.3 trillion per year in international climate finance from both public and private sources for developing countries by 2035 (UNFCCC, 2025b). The focus is on scaling up external financial flows (i.e., grants, concessional finance, and non-debt-generating instruments) from developed to developing countries, rather than counting domestic investments made within those countries themselves.

Yet despite these advances, climate finance flows remain far below what is needed. Estimates from the Independent High-Level Expert Group (IHLEG) suggest that emerging and developing economies (excluding China) will require between \$2.3 trillion and \$2.5 trillion annually by 2030 to stay on track with climate goals – an order of magnitude above current levels (Bhattacharya et al., 2024).

While much of this climate finance gap stems from the formidable political difficulties of agreeing on the required scale of transfers from developed to developing countries, there are also persistent gaps and weaknesses in how the Paris regime interacts with key international financial institutions (IFIs) that could help address this shortfall. While the Paris Agreement helped inspire regulatory change, its linkages to major financial institutions remain fragmented, under-institutionalised, and overly reliant on voluntary initiatives. Strengthening this connection is essential to delivering the objectives of the Paris Agreement.

### **Multilateral development banks (MDBs)**

Among international financial institutions, multilateral and bilateral development banks are furthest along in incorporating climate objectives into their operations. However, this progress remains too slow, too fragmented, and too limited in scope. The core question is no longer how much climate finance MDBs are mobilising. That approach often leads to false binary trade-offs – for example, between climate and health or education within Official Development Assistance (ODA) – and obscures the structural issue.

The more relevant question is how to align all MDB activities (loans, guarantees, grants, and investments) across all sectors (energy, transport, buildings, agriculture, industry, financial systems) with the goals of the Paris Agreement. This also means improving the leverage ratio between public and private finance, especially for mitigation. Current MDB leverage ratios (roughly \$1 of public finance mobilising \$0.37 of private finance for mitigation) must be improved (Alayza et al., 2024).

For adaptation, the focus must be on scaling grant-based finance, concessional lending, and insurance mechanisms. According to the United Nations Environment Programme (UNEP), international public adaptation finance to developing countries rose from US\$22 billion in 2021 to US\$27.5 billion in 2022. While the absolute volume and share of grants has grown, loans still account for 62% of adaptation finance, with approximately one-quarter of these being non-concessional, underscoring the ongoing reliance on debt-based financing mechanisms (UNEP, 2024b).

### **The IMF, the BIS, and the FSB**

One of the defining shifts between 2015 and 2025 is that climate has become a macro-critical issue, affecting fiscal and monetary policy, balance-of-payments dynamics, inflation expectations, and financial risk profiles. These are core concerns for both the International Monetary Fund (IMF) and the Bank for International Settlements (BIS), yet while progress is underway, their responses remain nascent and largely non-binding.

The IMF is actively integrating climate considerations into Article IV surveillance and lending programs. Then, it runs a Climate Policy Diagnostic (CPD) to help countries in identifying the institutional and legal frameworks their mitigation and adaptation strategies,<sup>19</sup> among other programmes. The BIS also expanded climate workstreams within central banking supervision. The NGFS, created in 2017, has grown to over 140 members, promoting voluntary climate risk integration.

Still, the global system lacks binding supervisory standards. Current reliance on disclosure frameworks and stress tests is insufficient. A robust regulatory action is needed, requiring the establishment of binding supervisory standards. The BIS, as institutional host to both the Financial Stability Board (FSB) and the Basel Committee on Banking Supervision (BCBS), is well placed to drive this agenda. A credible climate-financial governance mechanism would see the FSB and BCBS develop regulatory principles on climate-related risks – including capital adequacy, risk weighting, and prudential treatment of high-emissions exposures. These would then cascade down into national regulatory systems through implementation by central banks and financial supervisors, just as Basel III has been transposed into domestic banking regulation.

19 See the IMF, Climate Policy Diagnostic (CPD) at <https://www.imf.org/en/Topics/climate-change/climate-policy-diagnostic>.

There should be less left to national discretion: countries may retain flexibility in how they implement such rules, but not in whether they implement them. As with Basel, alignment with a core set of regulatory expectations must become the norm, not the exception. The goal is not just awareness of climate risk, but enforceable alignment of financial system rules with climate stability.

However, one should be realistic about the likelihood of such alignment in the current context. As recent efforts by US regulators to weaken the BCBS's climate task force make clear,<sup>20</sup> Washington's stance under the current administration is actively hostile to embedding climate considerations in global financial regulation. Other countries might well seek ways to move forward without the United States – but given the central position of the United States in the global financial system, its non-participation would necessarily constrain both the reach and effectiveness of any binding international framework.

### Central banks

Central banks are increasingly acknowledging that climate change poses systemic risks to financial and macroeconomic stability – threats that fall squarely within their mandates.

The current model focuses overwhelmingly on climate risk disclosure and stress testing, aimed at protecting financial stability. While important, this is inadequate to support the scale of investment needed for a rapid transition. Maintaining the principle of 'market neutrality' is incompatible with the scale and urgency of the climate challenge; instead, central banks must take a more proactive stance in steering capital toward the low-carbon transition (Diggle and Bartholomew, 2021).

However, the ability of central banks to act effectively is constrained by their institutional mandates and the need to remain independent of politically determined climate goals (Masciandaro and Russo, 2022). While central banks cannot mitigate climate change alone, they have a critical role in integrating forward-looking climate risk analysis into financial stability frameworks and coordinating with governments, markets, and civil society to align economic systems with climate resilience (Bolton et al., 2020).

For starters, they should recognise investments in mitigation and adaptation as productive assets: investments that protect growth from climate impacts, boost innovation, and generate long-term savings in health, infrastructure, and disaster response – either in the short term or the medium term.

20 "US pushes financial regulators to backtrack on climate risk project", *Financial Times*, 9 May 2025 (<https://www.ft.com/content/c6dca292-ebc0-40a9-93d5-477e3b05e8b3>).

Central banks should also ensure that countries and businesses that invest in the transition can borrow at a lower cost than those in the continuation of the high-carbon emitting economy. This is, however, more easily said than done. As of now, the cost of capital for green investments remains significantly higher than for fossil fuels in many emerging markets, due in part to risk perceptions and macroeconomic imbalances (Sachs et al., 2025).

The issue is the subject of a growing academic literature – including work by Schoenmaker and McKechnie (2024) on integrating climate targets into central bank mandates, and by Fornaro et al. (2024) on how monetary frameworks can support the transition.

Such reforms require both technical innovation and political leadership from pioneering central banks, particularly those in the Global North and South that are willing to experiment with new tools.

### **Strengthening institutional architecture**

The need to institutionally align the Paris Agreement with the broader architecture of global finance is clear – as outlined above in relation to both development banks and macro-financial regulators. The question is where and how this alignment should now be brought about.

One option is through the COP process. COPs already play a coordinating role in relation to MDBs, the Green Climate Fund, and the Global Environment Facility. Yet, while central to climate diplomacy, COPs are ill-suited to drive financial system transformation because of two key limitations. First, climate finance negotiations are highly polarised between developed and developing countries. Second, COP delegations are primarily composed of environment ministries which typically do not have the mandate to lead on financial regulation, investment alignment, or macroeconomic strategy.

Aligning all financial flows with the goals of the Paris Agreement, as mandated by Article 2.1(c) of the Agreement, requires a shift in lead actors. Finance ministers and central bank governors should be brought to the centre of the process. Discussions on the mobilisation of public climate finance can reasonably remain under climate ministries, supported by their finance counterparts. But aligning private capital, regulatory frameworks, and macroeconomic governance requires the opposite: finance ministries leading, informed by climate expertise.

There are two potential reform paths. The first is within the COP process itself, by granting finance ministries a formal negotiating and decision-making role, expanding beyond the informal Coalition of Finance Ministers for Climate Action. This would embed macroeconomic and financial governance at the heart of the climate regime. The second is outside of the COP process by creating a new institutional interface with a mandate to coordinate across climate and finance regimes. This interface could serve as a platform for regulatory alignment, financing strategies, and policy innovation.

If reform through the COP process proves procedurally unworkable, alternatives must be found. The G20 is often proposed, but it excludes many climate-vulnerable countries – some of which are among the most ambitious and exposed. A UN-hosted process may offer a more inclusive and legitimate platform, provided it can overcome inertia and fragmentation.

*Reconstituting a fragmented system: A unified, more accountable Action Agenda*

Since COP26 – and more acutely, after COP28 – the Global Action Agenda has become bloated and directionless. As of May 2025, the UNFCCC’s Global Climate Action portal currently lists 475 initiatives (UNFCCC, 2025a) – including countries, cities, businesses, and coalitions – engaged in voluntary climate initiatives. While many of these efforts are serious and of high integrity, the aggregate impact suffers from severe duplication, weak coordination, and insufficient accountability. The signal of meaningful action is increasingly lost in the noise.

Neither the UN nor civil society has been able to impose coherence or ensure integrity. This vacuum has fuelled accusations of greenwashing, leading many companies to adopt a strategy of ‘greenhushing’: continuing limited action while publicly stepping back from climate claims.

A first step towards reform is rationalisation of this ecosystem. Initiatives should be streamlined, and be verifiable, measurable, and clearly linked to intergovernmental processes. The current sprawl must be replaced by a single, coherent Action Agenda – with clear norms for participation and minimum standards for credibility.

Then, standards and norms should be part of a single, coherent framework for the participation of non-state actors, including businesses, financial institutions, cities, regions, and civil society organisations. Only those meeting minimum standards should be recognised as contributing to the Paris Agreement – and only they should have a seat at COPs. Voluntary initiatives must give way to regulatory frameworks. It should be possible to achieve this shift at COP30 in Belém, if political leadership – ideally under the UN – is willing to impose order on a system that urgently needs it.

*The untapped potential of subnational actors*

The Paris Agreement was shaped by the insight that international commitments are forged not only through negotiations between states, but also through domestic political dynamics – as Robert Putnam’s ‘two-level game’ theory describes (Putnam, 1988). In today’s climate regime, that dynamic has evolved into a ‘three-level game’, in which subnational actors – including cities, regions, and devolved governments – operate across local, national, and international arenas, helping to shape ambition, implementation, and diplomacy itself.

This distributed structure strengthens the system's resilience and expands the scope for agency beyond national governments. As Elinor Ostrom argued, polycentric governance – in which multiple centres of authority overlap and interact – enables greater adaptability in times of disruption (Ostrom, 2010). The Paris framework was built to accommodate such decentralised agency – as a critical 'safety net'.

The "We Are Still In" coalition that emerged after Donald Trump's 2017 withdrawal from the Paris Agreement illustrates both principles.<sup>21</sup> US states, cities, universities, and companies publicly reaffirmed their commitment to the Agreement's goals, continued to take policy action within the constraints of their legal mandates, and engaged in direct international diplomacy – including informal participation at COPs. They effectively revoked their delegation of representation to the federal government and asserted alignment with an agreement their own national administration had exited. Their actions demonstrated both the resilience of polycentric governance and the growing diplomatic capacity of subnational actors (Murthy, 2019), even in opposition to federal policy.

Subnational governments are not merely implementers of national policy, rather they are critical actors in an increasingly complex and layered system of climate governance (Kellner et al., 2024). Networks like C40 and the Under 2 Coalition have developed climate plans aligned with the Paris Agreement's targets and timelines (e.g., net-zero by mid-century), but have also influenced international diplomacy. Ahead of COP28, these networks played a central role in securing the adoption of a global goal to triple renewable energy capacity by 2030, despite opposition from fossil fuel-exporting countries.

Yet in practice, they remain underutilised and insufficiently integrated into national and international frameworks. They possess core competencies in domains central to mitigation and adaptation – transport, housing, land use, energy, and infrastructure – and their proximity to citizens allows for more participatory, responsive policymaking. But too often, they are left to implement strategies they had little role in shaping.

Two core reforms should be considered to unlock subnationals' potential and recognise their role within the three-level game. First, they should be systematically involved in the formulation of NDCs – not only in setting targets, but also in shaping the national frameworks for planning, regulation, infrastructure coordination, and finance that condition their capacity to implement climate policy. In the absence of such involvement, a persistent disjuncture arises between national ambition and local implementation, undermining the effectiveness and credibility of climate commitments.

The voluntary CHAMP initiative offers an emerging model, with participating countries pledging to integrate subnational governments into their NDC processes. However, more formalised mechanisms are required to ensure consistency and accountability. One concrete step would be to require Parties to include in their NDC submissions a dedicated

21 "America's pledge", We Are Still In ([https://unfccc.int/sites/default/files/resource/212\\_We%20Are%20Still%20In%20and%20Americas%20Pledge\\_Talanoa%20Dialogue%20submission\\_2%20April%202018.pdf](https://unfccc.int/sites/default/files/resource/212_We%20Are%20Still%20In%20and%20Americas%20Pledge_Talanoa%20Dialogue%20submission_2%20April%202018.pdf)).

section outlining the processes and outcomes of subnational engagement. This could be supported through revised UNFCCC guidance and integrated into the Enhanced Transparency Framework (ETF). In parallel, national institutional arrangements – such as intergovernmental climate councils or coordination bodies with subnational representation – should be promoted to facilitate sustained multilevel governance and policy coherence.

Second, their actions and contribution should be formally recognised in the Global Stocktake (GST) – the five-yearly accountability mechanism of the Paris Agreement – to ensure that the breadth of climate action underway is accurately reflected and to surface implementation gaps that may require coordinated responses. Many subnational governments have adopted targets and implemented policies that exceed national ambition, particularly in high-capacity jurisdictions, yet these efforts remain largely invisible within the formal UNFCCC process. Their omission from the GST risks undercounting progress, distorting assessments of collective effort, and overlooking structural barriers faced by local actors. Formal recognition would not only improve the completeness and credibility of the GST, but also create a mechanism through which the obstacles faced by subnationals – for instance, lack of access to climate finance or misalignment with national infrastructure planning – could be flagged and addressed at the appropriate level. To facilitate this, the UNFCCC should encourage Parties to report on subnational action as part of their Biennial Transparency Reports, thereby strengthening the evidence base feeding into the GST and institutionalising multilevel accountability.

#### *Sharpening national incentives*

As already set out, the Paris Agreement is predicated on the understanding that national sovereignty and the collective provision of a global public good are not fundamentally incompatible. True sovereignty – defined as the ability of societies to shape their own future – is increasingly dependent on effective climate cooperation (Bakker, 2018; Schrijver, 2024). Pooling aspects of sovereignty, particularly in areas like emissions reduction and financial alignment, has become a strategic necessity for preserving long-term national autonomy.

Nonetheless, tension persists between the right to autonomous domestic policymaking and the obligations entailed by global climate targets. This tension is structural as it is embedded in the nature of the climate crisis, but it is not unmanageable. One of the core innovations of the Paris regime was its pragmatic attempt to reconcile national sovereignty with global ambition. By anchoring climate action in NDCs, the Agreement enabled countries to retain control over their domestic policy choices – while committing them to a shared set of global objectives. The upcoming cycle of NDCs offers a critical test of whether this balance can be sustained in an era of heightened geopolitical and economic fragmentation.

The next round of NDCs, due at COP30 in Belém, will be the most consequential since the Agreement's inception. According to the first Global Stocktake, current national plans are collectively insufficient to limit global warming to 1.5°C or even 2°C. As mandated by the Paris Agreement's five-year ratchet mechanism, countries are expected to submit new NDCs aligned with the findings of the first Global Stocktake. These NDCs, which will cover the period up to 2035, must therefore represent a material step up in ambition – not just in long-term targets, but in implementation strategies, investment frameworks, and governance capacity. A true third generation of NDCs should function as transformational economic development strategies.

The vast majority of countries have yet to submit updated NDCs but are expected to do so by the time of COP30. Of those that have, the submissions have been mixed: a handful of countries, such as the United Kingdom, have offered ambitious updates compatible with their fair share of total contribution, while others – including Canada and Japan – have tabled incremental or unambitious plans.<sup>22</sup>

If fully closing the 'ambition gap' at Belém seems unlikely, it is partly because of the incentives that states currently face. Many of these reflect the fractured and more nationalist politics of the present moment. But others stem from structural deficiencies in the design of the system itself – shortcomings that future reforms could help to address, if not entirely resolve. In particular, the competitive asymmetries created by uneven climate ambition and policy implementation remain a serious barrier to progress (Mehling et al., 2018).

While many governments are investing in green industrial strategies and clean energy innovation – and reaping real economic benefits from doing so – the distribution of costs and benefits is uneven. Major differentials in energy prices and production costs are emerging between countries that are pressing ahead with deep decarbonisation and those that are not. These asymmetries can fuel domestic resistance, especially in exposed sectors or regions, and create headwinds for the jurisdictions leading the transition. In a world where the United States is actively expanding fossil fuel production while others pursue decarbonisation, these challenges are likely to intensify.

To counteract these pressures and support ambitious countries, new mechanisms are needed. Article 6.1 of the Paris Agreement provides a legal basis for voluntary cooperation between countries to enhance ambition and promote sustainable development. This could include the formation of trade and investment alliances between climate-forward economies – helping to preserve competitiveness, secure supply chains, and support shared infrastructure. It also offers a foundation for co-investment frameworks and differentiated transition pathways, tailored to national contexts but coordinated around common objectives.

22 See Climate Action Tracker, "United Kingdom 2035 NDC" (<https://climateactiontracker.org/countries/uk/2035-ndc/>) and "Canada 2035 NDC" (<https://climateactiontracker.org/countries/canada/2035-ndc/>).

Such instruments will not eliminate the tension between sovereignty and collective action. But they can help shift the incentives that shape national climate choices – from risk to opportunity, from fragmentation to alignment. At a time of mounting political pressure and economic divergence, strengthening these tools is essential to sustaining the Paris Agreement’s core logic: progressive ambition through iterative alignment and learning.

## COALITIONS OF THE WILLING - AND OF THE DOING

In addition to the necessary reforms to the global climate governance system anchored to the Paris Agreement, coalitions of the willing offer a compelling and immediate way to accelerate progress. Just as shifting geopolitical alliances are reshaping defence cooperation, climate governance must adapt to a world in which multilateral processes constrained by consensus rules can no longer deliver at scale. Multilateral forums like the COPs are too often blocked by deliberate obstruction or compromise outcomes diluted to reflect the lowest common denominator – often lower today than in 2015.

In contrast, plurilateral, smaller, more agile coalitions – if strategically designed – can act swiftly, build technical and financial momentum, and create real-world impacts (Feist, 2023). As discussed by Blanchard and Pisani-Ferry (2025) and Bolton et al. (2024), such coalitions can complement the Paris process by circumventing the free-rider problem inherent in global agreements by combining carrots (trade benefits, technology sharing) with sticks (carbon border adjustments on non-members), and can create a ‘critical mass’ of participants, leveraging collective action to incentivise broader global participation.

However, to be truly transformative, these coalitions must evolve. Ambition alone is not enough. In the earlier norm-setting phase of global climate diplomacy, this ambition was valuable to gather early movers. In the current implementation phase, these coalitions must become coalitions of the doing: practical, delivery-oriented alliances that create and distribute incentives for action – particularly for first movers in the transition.

There is no single blueprint for them to work. But across sectors and geographies, the coalitions that matter most now are those that link ambition to concrete economic opportunity and structural change.

Two of the most promising domains for this coalition-based approach are: central banking and financial regulation (as already discussed in this chapter), and trade and investment policy (discussed below). In both, a coalition-based approach can unlock faster progress than is currently possible through formal multilateral channels. For regulators and financial institutions, it can mean aligning rules, standards, and capital flows to reflect the realities of the transition – reducing the cost of capital for green investment and raising it for the high-carbon status quo. For states, businesses, and investors, this can mean trade and investment deals that bring together emissions reduction and resilience, secure supply chains, and create clear win-win economic gains.

## Trade and investment agreements

Trade and investment agreements represent a powerful but underutilised tool for advancing climate goals. Embedding the objectives of the Paris Agreement at the centre of these could leverage their power as engines of economic growth and development to drive decarbonisation and climate resilience.

Today, trade and investment agreements are not oriented towards the objective of reaching climate goals, quite the contrary. Most reinforce the high-carbon legacy of past economic structures. The Energy Charter Treaty is a stark example: it allows fossil fuel investors to sue governments for compensation when climate policy threatens their profits, thus entrenching high-carbon infrastructure and disincentivising the policy reforms essential for the energy transition (Di Salvatore, 2021).

More broadly, many trade deals fail to incorporate climate benchmarks, instead cementing rules that prioritise short-term economic efficiency over long-term climate resilience.

But there is a way in which trade and investment agreements can be turned into a vehicle for decarbonisation and climate resilience. It would require a profound change in approach, and to turn their logic upside down – but it is feasible. One approach is to include a ‘Paris compliance clause’ into trade deals: a mandatory clause specifying that the other clauses only apply if a country complies with its obligations under the Paris Agreement (including meeting the obligation to submit a new, more ambitious NDC – and the underlying policy detail – every five years).

Another complementary approach is to negotiate sector-specific and value chain-specific trade and investment agreements (as argued by McWilliams, Tagliapietra and Zettelmeyer in Chapter 6 of this volume) and to negotiate energy-, agriculture- or mining-specific deals, which consider both the need to decarbonise energy and the economy and the need to adapt to climate impacts. These trade and investment agreements would incentivise the production and exchange of low- and zero-carbon goods and services, develop complementarities, negotiate the distribution issue along the value chain of components and essential materials, and penalise the production and exchange of high-carbon options. In the current turmoil, pioneering such agreements it should be seen as an essential opportunity for Europe and others to find new partners.

These proposals are fundamentally different from an attempt of aligning climate and trade policies such as the Carbon Border Adjustment Mechanism proposed by the European Union. The CBAM is a unilateral measure focused on protecting EU industry rather than promoting collective ambition by taxing high-carbon imports and adjusting at the border for different levels of stringency of climate policies.

A carbon and climate resilience club, on the other hand, would be negotiated in a plurilateral manner. It would ensure that participants to the club can enjoy the benefits of moving first in the energy and climate transition. In this respect, Nordhaus' model may yet have a future – not as a substitute for the Paris Agreement, but as a complementary tool for preserving momentum and rewarding first movers in a more fragmented and challenging global context.

### **Information war, cultural battle, and political polarisation: How to fight back and what can be done at the international level**

The most significant – and in many ways, most hopeful – change since the negotiation of the Paris Agreement in 2015 has been the scale and strength of the climate movement within societies, across both the Global South and North. Public mobilisation is no longer a niche concern of environmentalists, but a broad-based force spanning generations, sectors, and political contexts. This shift represents not only a fundamental change in the landscape of climate politics, but the most powerful lever for getting out of the current geopolitical and governance impasse.

The youth climate strikes of 2019 catalysed a wave of mobilisation that has extended far beyond activism. A new generation of climate actors has emerged across government, finance, business, and civil society. Public consciousness of climate risks and support for climate action are far higher today than they were a decade ago.

There is polarisation – and it is real. Resistance to climate policy is often more vocal and ideologically entrenched than in 2015. Populist leaders have instrumentalised climate scepticism, and in many cases, ill-designed policies have exacerbated feelings of injustice. But this should not be confused with a collapse in support. That interpretation is both politically convenient and empirically wrong.

Fundamental – but underappreciated – is the fact that the global climate movement remains strong. A survey of over 130,000 people across 125 countries – representing 96% of global emissions – found that 89% support stronger climate action (Lamb et al., 2020). Many political and business leaders have misread frustration with the fairness of transition policies as a rejection of climate action itself. In France, for example, 79% of respondents to an opinion poll agreed that “the poorest are paying for the climate and energy crisis while the richest are responsible for it”.<sup>23</sup> They have a point. Globally, the wealthiest 1% emit as much as the poorest 66% combined (Chancel et al., 2024). Even in countries with lower historical or per capita emissions, domestic inequality remains stark. Introducing regressive policies on top of these disparities will inevitably trigger resistance.

23 “Comprendre le nouveau clivage écologique : données inédites”, Le Grand Continent, 7 November 2025 (<https://legrandcontinent.eu/fr/2023/11/07/comprendre-le-nouveau-clivage-ecologique-donnees-inedites/>)

This is the political terrain on which climate action now stands. Any large-scale transformation depends on two dynamics. The first is a coalition of early movers: those driving investment, innovation and leadership. The second is a broader group of citizens who may not lead, but whose support is indispensable – as voters, consumers, and investors. That ‘soft centre’ of public opinion cannot be ignored or left behind.

In a world of growing nationalism and contested authority, depolarising climate politics is now a strategic necessity. Climate action must be framed not as a partisan project or elite agenda, but as a shared national interest – socially fair, economically rational, and geopolitically smart. If climate change action remains culturally coded and politically fragile, it will not survive the next wave of disruption.

## CONCLUSION

This is a profoundly difficult moment for both climate governance and the international order. In this context, the Paris Agreement remains indispensable – not because it is sufficient, but because it is still the most legitimate, durable, and adaptable framework we have. It must be defended against rollback and strengthened to confront the implementation and coordination challenges now ahead.

The geopolitical environment has shifted dramatically. The trade confrontation initiated by the United States is forcing a reconsideration of the relationship between economic policy and climate action. The coming years will be marked by volatility – overlapping crises, fragmented alignments, and contested multilateralism. In this landscape, the Paris Agreement’s role as a clear and legitimate signal becomes more important, not less.

But signal alone is not enough. New forms of cooperation will be needed to deliver results: coalitions of the willing, sectoral alliances, and trade-linked agreements that reinforce climate ambition. These must be linked back to the core Paris architecture, not treated as substitutes. At the same time, a deeper reform of the multilateral system – one that connects climate, peace, and economic security – must remain a long-term objective.

COP30 in Belém, marking the tenth anniversary of the Paris Agreement, offers a critical moment to advance on both tracks: short-term strategies to accelerate delivery, and longer-term reforms to rebuild the institutional foundations of global climate governance.

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# Global climate cooperation after 2024: A proposal for a heavy industry climate coalition

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With the election of Donald J. Trump in November 2024 for a second, albeit non-consecutive, presidential term, it has become clear that the United States will not take a leading role on global climate cooperation in the coming years. The Biden administration had reaffirmed the United States' commitment to the Paris Agreement, and coupled this symbolic action with substantial climate policy aimed at domestic decarbonisation through both tax and regulatory levers. In contrast, both the prior and incoming Trump administrations' disdain for the United Nations Framework Convention on Climate Change (UNFCCC) process reflects an explicitly dismissive attitude to climate change as a policy problem. The second Trump administration has withdrawn from the Paris Agreement and initiated the roll-back of US regulations on power sector and tailpipe emissions; upcoming Congressional action (still unresolved at the time of this writing in mid-May 2025) may also repeal some or all of the Inflation Reduction Act's clean energy tax subsidies.

This chapter explores the future of global climate cooperation in light of recent developments in the United States, making two key arguments. First, following the reversal of US federal climate policy and its withdrawal from global climate cooperation, US emissions progress will depend instead on state-level policy action as well as dynamics resulting from prior policy adoption and technical change.

Second, because the world is falling short of necessary climate policy action, it will be useful to develop mechanisms that incentivise bolder climate policy. While the Paris Agreement and UNFCCC process have made important strides, the free-rider problem hampers global collective action. Toward this end, we suggest a heavy industry climate coalition – where 'heavy' industry refers to aluminium, iron and steel, cement, and fertilizers – as an important step forward. In a heavy industry climate coalition, countries would 'join' by committing to apply a carbon fee (or an equivalent emissions

trading system) to emissions-heavy industries, and they would couple that fee with a carbon border adjustment mechanism. Coalition participants could also pair carbon-pricing sticks with carrots, including market access, climate finance commitments, and technology transfer agreements.

This coalition approach has key advantages. First, for coalition members, industrial carbon pricing can reap large emissions reduction benefits while raising fiscal revenues. We estimate that a heavy industry climate coalition based on a modest carbon price has the potential to reduce worldwide emissions by 1.5%, or 570 million tonnes (Mt) per year, if the 17 G20 jurisdictions that presently employ some form of carbon pricing participate, or as much as 2.7%, or 1030 Mt per year, if participation covers the vast majority of the world. Second, the coalition mechanism will encourage policy adoption momentum by giving coalition ‘members’ preferential market access and other benefits relative to ‘non-members’. Indeed, this latter feature provides something that the UNFCCC process has so far lacked: an enforcement mechanism to counter the free-rider problem that stymies global collective action in tackling climate change.

The EU Carbon Border Adjustment Mechanism (CBAM) provides a useful starting point in countering free-rider incentives, but more work is needed for this approach to suit the rest of the world. First, the coalition could support harmonisation of measurement, monitoring, and verification criteria as well as administrative processes across jurisdictions to reduce compliance and administration costs. Absent coordination, global firms risk facing dozens of disparate regimes and are wary of revealing sensitive information to foreign governments. A more predictable, transparent, and administratively simpler approach would generate less opposition from the business community. Second, the ‘common but differentiated responsibilities’ principle central to the UNFCCC climate process can be more effectively honoured through a plurilateral approach. By agreeing on differentiated obligations for coalition membership that are based around commonly accepted metrics of economic development, a plurilateral agreement can better meet the needs of poorer countries, jurisdictions that have limited resources and that often bear little to no responsibility for climate change.

The European Union has been understandably loath to violate WTO principles regarding non-discriminatory trade measures. Yet, in the context of two international agreements, in which the principle of one (common but differentiated responsibilities) may be in tension with the principle of the other (non-discrimination), countries can find a sensible middle ground that encourages broad participation consistent with countries’ capacities and the overall objectives of both the climate and trade treaties. Further, the WTO does contain [special provisions](#) that allow for members to treat developing countries more favourably.<sup>1</sup>

1 [https://www.wto.org/english/Tratop\\_e/dda\\_e/status\\_e/sdt\\_e.htm](https://www.wto.org/english/Tratop_e/dda_e/status_e/sdt_e.htm)

This chapter will describe how a heavy industry climate coalition can be negotiated and implemented, and how it can eventually serve as a stepping stone to the resolution of the world's biggest global collective action problem. While negotiation will not be easy, it is feasible. At present, the G20 jurisdictions account for about 80% of global carbon emissions, and most G20 countries are either utilising carbon pricing approaches or working towards that end (the exceptions are the United States, Saudi Arabia, and Russia, which together account for about 20% of G20 emissions).<sup>2</sup> Together, they can create a climate coalition that incentivises membership through both sticks (tariffs on carbon-intensive goods for non-members) and carrots (market access, technology transfer, and climate finance for members).

The Trump administration's stance on climate policy signals a retreat from US leadership in global efforts, leaving a vacuum for others to fill. Paradoxically, the absence of US involvement could facilitate coordination on price-based climate policies by reducing conflicts tied to US preferences. Still, nothing in our proposal precludes participation by the United States, and US heavy industry firms might have substantial incentives to participate if their competitors in markets around the world are part of the coalition.

## US CLIMATE POLICY AFTER 2024

During the Biden administration, the US government built on prior tax and regulatory policies in passing and implementing the largest climate bill in US history, the Inflation Reduction Act (IRA). The IRA included more than \$120 billion in public investment on climate projects, including conservation and carbon sequestration in the agriculture and forestry sectors, energy efficiency, industrial decarbonisation, and green lending. The IRA also provided extensive clean energy tax credits, intended to incentivise clean electricity production and investment, carbon capture, clean fuels, energy efficiency, electric vehicles (EVs), and clean manufacturing activity. The original estimate of the budgetary costs of these credits was about \$270 billion, but Congressional scorekeepers have since more than doubled their estimates, and outside estimates are often even higher (Bistline et al., 2023; Goldman Sachs, 2023; Penn Wharton Budget Model, 2023).<sup>3</sup>

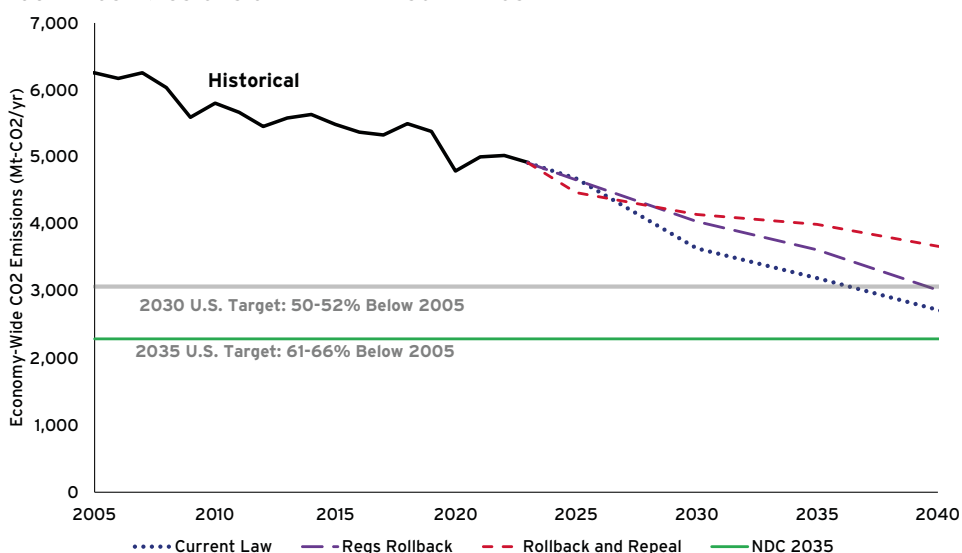
2 India and Brazil are implementing carbon pricing regimes; 15 other G20 members already use some form of carbon pricing. As of 2023, the G20 includes the African Union; the European Union is also a member of the G20. The European Union employs a carbon pricing regime, but most African Union nations do not. Our comparison of emissions is based on Climate Watch data for 2021. We consider carbon dioxide emissions including land use-change and forestry.

3 For a discussion of the evolution of these estimates, see Box 3-1 in Congressional Budget Office (2024). Outside estimates have some methodological differences relative to official scores.

Virtually all of the IRA clean energy tax provisions are uncapped; they are only time-limited, with most clean energy investments eligible for tax credits for as long as a decade after passage of the law.<sup>4</sup> In addition, major climate regulations can amplify the deployment of tax-favoured technologies, such as the Biden administration Environmental Protection Agency (EPA)'s standards on tailpipe CO<sub>2</sub> emissions standards for vehicles, fossil fuel power plants, and biofuels.<sup>5</sup> In March 2025, the Trump EPA initiated a review of these regulations, which could result in regulatory revisions that reduce their ambition.

The Biden-era tax and regulatory steps are forecast to reduce US emissions substantially relative to the prior status quo, or a scenario where such steps were reversed. Figure 1, drawing from analysis in Bistline et al. (2025), shows estimates of the US emissions path under three scenarios: the US current law scenario (which assumes Biden-era tax and regulatory policies continue); a regulatory rollback scenario (which assumes tax policies continue, but Biden administration power plant and tailpipe regulations are rolled back); and a regulatory and repeal scenario (which assumes regulations are rolled back alongside a full repeal of all IRA clean energy tax credits).

FIGURE 1 US EMISSIONS UNDER THREE SCENARIOS



Source: Bistline et al. (2025).

- 4 The IRA's main clean electricity provisions remain in place until an emissions target is achieved, which is projected to occur after 2040 (Bistline et al., 2023). Past experience with the investment tax credit for solar power, for example, illustrates how clean energy innovation can enable much greater deployment of a form of tax-favoured investment than initially projected by the scorekeeper - in the case of solar, about an order of magnitude more than initially projected (Aldy, 2025).
- 5 Layering regulation on the IRA tax provisions would double the investment in carbon capture technology in the power sector relative to the IRA subsidies alone (Aldy, 2025).

As is apparent from Figure 1, US emissions are on a declining trajectory, due to prior policy steps and technological progress. However, the downward trajectory is insufficient to meet US 2030 Paris Agreement emissions reduction goals, or the Biden administration's 2035 goals announced in December 2024, even under current tax and regulatory policies. Under other scenarios – either regulatory rollback, or rollback and repeal – US emissions reductions are more modest, falling even further short of US climate policy targets.

The Trump administration is likely to have far-reaching effects on US climate policy. The administration announced its plans to withdraw from the Paris Agreement and undertake a host of executive branch deregulatory actions in two day-one executive orders.<sup>6</sup> Indeed, regulatory rollback is likely, whereas a complete IRA credit repeal may be less likely, for two reasons.

First, the regulatory steps require only action by the executive branch, not Congress, and the Republican margins in Congress (53-47 in the Senate and, pending special elections, 220-213 in the House) are very tight, making Congressional action more difficult. With deregulation, the executive branch may act without Congress, but it must undergo a process of public engagement, which takes time, as evident in similar efforts in the first Trump administration (Aldy, 2017). Under some statutory authorities, such as for fuel economy standards, deregulation does not imply no regulation, but simply less-ambitious regulation. The Trump administration, however, has also increased uncertainty over the permitting of clean energy technologies, which could chill investment even before formal policy actions.

Second, the clean energy tax credits have benefited many Republican constituencies, and IRA investments have been disproportionately occurring in either 'red' (i.e., Republican) or 'swing' states, making it difficult for Congress to vote to reverse these large tax benefits.<sup>7</sup> For example, 18 Republican Members of Congress sent a 2024 public letter to the Speaker of the House of Representatives that noted: "Energy tax credits have spurred innovation, incentivized investment, and created good jobs in many parts of the country – including many districts represented by members of our conference".<sup>8</sup> There may even be room for some areas of bipartisan progress in Congress, including around issues like geothermal energy, nuclear energy, carbon capture, and permitting reform for energy infrastructure such as energy transmission and interconnection as well as pipelines for CO<sub>2</sub> and hydrogen.

6 <https://www.whitehouse.gov/presidential-actions/2025/01/putting-america-first-in-international-environmental-agreements/>; <https://wci-inc.org/our-work/program-design-and-implementation>

7 See, for example, <https://www.ft.com/content/06fcd3dd-9c39-48d3-bb08-6d75d34b5ed1>

8 See <https://garbarino.house.gov/sites/evo-subsites/garbarino.house.gov/files/evo-media-document/FINAL%20Credits%20Letter%202024.08.06.pdf>. Twenty-one Republican Members of Congress penned a similar letter in March 2025 to the Chair of the House Ways and Means Committee.

Still, the fiscal trade-offs will be stark in the 2025 tax debate, and changes to the tax code are nearly inevitable due to the looming expiration of much of Trump's 2017 tax legislation, the "Tax Cuts and Jobs Act". Indeed, the 2017 legislation was designed to permanently enact the less popular provisions (corporate tax cuts), while the more popular individual and pass-through business provisions were made explicitly temporary, reducing the scored budgetary costs of the legislation. Thus, the Republican-controlled Congress is expected to make every effort to extend the tax cuts, but the fiscal costs of extension are huge, approximately \$5 trillion over ten years (Committee for a Responsible Federal Budget, 2024). Since IRA repeal could score as generating more than \$700 billion, that revenue gain – alongside the inevitable attraction of undoing a signature Biden effort – may tempt legislators toward substantial or even full repeal (U.S. Department of the Treasury, 2024).

Even under a full 'rollback and repeal' scenario, however, there are still reasons to expect an ongoing decline in US emissions. First, some IRA investments have already occurred and those will continue to generate emissions reduction benefits into the future, as will prior investments under earlier clean energy tax credits. Second, technological change and business model development (both in the United States and abroad) will continue to drive clean energy adoption, as clean energy alternatives become less expensive relative to carbon energy sources. Indeed, these factors mitigated emissions rebound during the first Trump administration (Aldy, 2017).

Finally, there is an important role for US policy action by US states, cities, or tribal nations, and voluntary actions by US businesses can also be significant. For example, California has long been a leader in environmental regulatory efforts, and its policies have important spillover effects. Companies may not want to make a special 'clean' product for California alone, nor will they want to forsake such a large market (as California has the economic size of a large country), so they often choose to make products for the country (and the world) that meet California's higher standards. Other states may also follow California's regulatory standards; for example, the California zero-emission vehicle standards have been adopted by 17 states and Washington, DC, representing 37% of new, light-duty vehicle sales in the United States.<sup>9</sup> This dynamic was indeed responsible for important reductions in automotive pollution, and courts have recently upheld California's right to impose higher regulatory standards.<sup>10</sup>

9 This was calculated by the authors using data from the Alliance for Automotive Innovation (<https://www.autosinnovate.org/resources/insights>).

10 For one news story, see <https://www.pbs.org/newshour/politics/court-upholds-californias-authority-to-set-nation-leading-vehicle-emission-rules>. Related issues are currently before the US Supreme Court (see <https://www.eenews.net/articles/supreme-court-s pares-california-auto-emissions-waiver-for-now>).

Climate commitments have also been affirmed in many US states. In 2024, California supported a \$10 billion climate bond measure<sup>11</sup> and implemented new low carbon fuel standards,<sup>12</sup> the state of Washington upheld an emissions allowance system,<sup>13</sup> New York state continued to implement its ‘cap-and-invest’ programme,<sup>14</sup> and the Governor of Maryland introduced a sweeping climate executive order.<sup>15</sup> In prior years, US states and cities have formed coalitions, often alongside US businesses, committing to climate action. Some of these are even aimed at implementing carbon pricing, including the Western Climate Initiative<sup>16</sup> and the Regional Greenhouse Gas Initiative.<sup>17</sup> Thirteen states, representing about 20% of US electricity consumption, have cap-and-trade programmes covering the power sector with prices of at least \$25/tCO<sub>2</sub> by the end of 2024. Three of these states – California, Oregon, and Washington – extend these programmes to energy-intensive manufacturing industries, covering about 10% of US establishments in these industries.<sup>18</sup> A majority of US states implement renewable energy portfolio standards.<sup>19</sup> While some of these efforts are being challenged in US courts, they nevertheless demonstrate bottom-up state-level efforts.

## THE FUTURE OF GLOBAL CLIMATE COOPERATION

Even though there are reasons to hope for continued progress in US emission reductions, the outlook for US leadership on the global stage is poor. Leaders from other countries will need to use existing incentives and institutions, or create novel institutional designs, to accelerate progress in addressing climate change. Progress to date has been woefully insufficient. By one measure, current policy action implies a warming of 2.7°C by 2100, well above the Paris Agreement goal of 1.5°C (Climate Action Tracker, 2024). Further, many indicators are worrisome, including ocean temperature increases, alerts about the collapse of key ocean currents that regulate climate,<sup>20</sup> and escalating tolls from climate-related disasters.

While the world community appears nearly unified in recognising the nature of the problem and the kinds of policy steps that are needed in response, other factors inhibit progress. Foremost, there is a free-rider problem. Climate change is a truly global externality, and action in any one jurisdiction benefits the entire world. Thus, when

11 <https://www.kqed.org/news/12012256/californias-10-billion-climate-bond-ahead-with-a-strong-lead>

12 <https://ww2.arb.ca.gov/news/carb-updates-low-carbon-fuel-standard-increase-access-cleaner-fuels-and-zero-emission>

13 <https://apnews.com/article/washington-climate-law-repeal-initiative-vote-bbac4bb2601db447d783ba5c511c9cbd>

14 <https://nysfocus.com/2024/12/23/greenhouse-emissions-new-york-cap-and-trade>

15 <https://www.wypr.org/wypr-news/2024-06-05/maryland-governor-moore-mandates-statewide-climate-action-with-new-executive-order>

16 <https://wci-inc.org/our-work/program-design-and-implementation>

17 <https://www.rggi.org>

18 Appendix A describes how we arrived at this estimate.

19 <https://www.ncsl.org/energy/state-renewable-portfolio-standards-and-goals>

20 <https://www.euronews.com/green/2024/10/24/this-tipping-point-would-be-catastrophic-for-europe-but-scientists-are-unsure-when-well-re>

individual jurisdictions contemplate the costs and benefits of climate action, they recognise that they bear the entire costs of their own policies but reap a tiny sliver of the policy's ultimate benefits. This reduces the incentive to act, and jurisdictions are instead incentivised to free ride on others' effort (Barrett, 1994; Nordhaus, 1994).

Further, there is no enforcement mechanism within the UNFCCC Paris Agreement process. Countries make their own nationally determined contributions (NDCs) to emissions reductions, and these are monitored and assessed, but countries that fail to make sufficiently bold policy commitments, or that fail to follow through on their commitments, face no penalty. The 'pledge and review' strategy of the Paris Agreement relies on naming and shaming, but the threat of reputational risk is an insufficient motivator for costly action, and it is undermined by the intermittent participation of the United States, the largest historical emitter.<sup>21</sup>

Another hindrance is the absence of leadership. While 'leadership' is a difficult element to pin down, it generally entails a subset of large, economically important countries (and their associated leaders) that are willing to expend diplomatic effort and resources for an extended period of time in order to further cooperation. At certain moments in history, countries have been able to work together to solve collective action problems. One formative example is the formation of the Bretton Woods institutions – the World Bank, the IMF, and the General Agreement on Tariffs and Trade (GATT) – in the wake of World War II to encourage reconstruction and development after the war, greater financial stability, and improved global integration. Another example is the Paris Agreement itself, which was reached after arduous diplomatic efforts as well as prior failures. And a third example is the international tax agreement of 2021 (now being broadly implemented), which includes about 135 jurisdictions representing about 95% of the world economy.<sup>22</sup> This agreement committed governments to transformative tax policy changes that seek to better tax mobile multinational company profits.

## A HEAVY INDUSTRY CLIMATE COALITION

We propose a heavy industry climate coalition, arguing that it can help overcome the hurdles that impede international collective action. First, there are natural leaders in this space who would benefit from developing such a coalition. Second, and crucially, the coalition mechanism would help overcome the vexing free-rider problem by giving coalition members advantages relative to non-members, eventually incentivising broad policy action.

21 <https://ourworldindata.org/grapher/cumulative-co-emissions>

22 While the Trump administration issued a day one executive order withdrawing the United States, that order was toothless since Congress had already failed to implement the agreement, and a backstop provision will still extend the agreement to most large US multinational firms.

## How would a coalition work?

Under the proposed heavy industry climate coalition, members would commit to charging a fee, or a carbon price, on the direct carbon emissions associated with the production of aluminium, iron and steel, cement, and fertilizer production (scope 1 emissions), as well as the associated electricity used in production (scope 2 emissions), affecting all production within their borders. The selection of these manufacturing industries reflects both their energy intensity and a desire for compatibility with EU and UK efforts. For these industries, members would also agree to impose carbon border adjustments (nondiscriminatory tariffs that apply domestic carbon price equivalents to imports) on non-member countries, but not to impose carbon border adjustments on other members.

Importantly, member countries would coordinate to develop common measurement, reporting, and verification standards as well as common administrative procedures. Metrics to assess and compare mitigation efforts should be comprehensive, measurable, replicable, and universal (Aldy and Pizer, 2016). The members would support a global scientific committee to refine methodologies and procedures on an ongoing basis. Setting such regulatory standards on a plurilateral basis is likely to generate more long-standing political support for the regulation; it can also counter the perception that the European Union is imposing its regulatory standards on others.

This effort would build on important work by the European Union on its Carbon Border Adjustment Mechanism (CBAM).<sup>23</sup> At present, the EU CBAM applies to scope 1 emissions in the aluminium and steel sectors, and both scope 1 and 2 emissions in the other CBAM sectors, but there is some thought of expanding the reach of the CBAM in the years ahead. Importantly, the EU CBAM credits exporting countries' carbon pricing in its tariff calculations. Thus, if an exporting country has a €20 per ton carbon price, and the European Union has a €80 per ton carbon price, the tariff will be based on the difference (€60 per ton). This regime rewards those countries with carbon prices with lower tariffs (and access to the European market, which offers a higher equilibrium price), and it also rewards cleaner production, as cleaner products naturally pay a lower carbon price, spurring decarbonisation efforts.

The EU CBAM represents an innovative solution to the problem of leakage. Absent border adjustment, countries may be reluctant to impose costs on their industries, since consumers may choose to import lower cost dirty products from abroad, or production may move abroad to avoid the cost-imposing regime. The CBAM is an answer to these concerns, albeit only a partial one.

23 We do not undertake a lengthy comparison with Nordhaus (2015), who proposes a climate club based on country climate policy ambition, using a uniform tariff on all goods as an incentive. For a discussion of that alternative, see Clausen and Wolfram (2023). A G7 climate club initiative put forward by Germany is described by Erbach and Scalamantrè (2023) through the European Parliamentary Research Service.

First, since carbon prices on exports are not rebated, EU firms may still face competitiveness issues in markets abroad. Second, most CBAM goods are inputs, not final products. If the carbon price becomes a sizable component of some final goods' costs, there will still be an incentive to move production offshore. This latter mechanism will be limited if the component carbon cost is small, or if the input goods are used in non-traded production such as domestic construction.

Our proposal builds on the EU CBAM, but recognises that a plurilateral (or even multilateral) process can improve the EU CBAM in several key respects. First, the EU CBAM has been criticised for being administratively burdensome, but a plurilateral agreement can act to address these concerns in an inclusive manner while ensuring that a complex web of different regimes does not proliferate, creating multiplied compliance and administrative costs. Second, a plurilateral process can better honour the principle of common but differentiated responsibilities.

Third, the EU CBAM, since it does not include export rebates and falls on input goods, still generates competitiveness concerns for EU firms. But a coalition would facilitate wider participation in the CBAM regime, reducing those concerns substantially. It would also enable a smoother extension of the CBAM to scope 2 emissions for all sectors, or eventually to other sectors beyond heavy industry. Finally, in general, a larger agreement creates stronger incentives for those outside the agreement to 'join', helping overcome the collective action problems that plague climate change mitigation and reducing remaining competitiveness concerns.

We believe that a focused, plurilateral approach could serve as a stepping stone to a more comprehensive, multilateral approach. However, as a matter of practicality, initial negotiations are likely to be limited to a more modest number of jurisdictions, such as a willing subset of either the G20 or the OECD. The convening body for such an agreement is discussed below.

### **How would the coalition encourage broad participation?**

The biggest advantage of a plurilateral approach is that it can address the 'common but differentiated responsibilities' principle that lies at the heart of the UNFCCC climate cooperation process, and addressing that concern would build support for participation in the agreement. We suggest several key elements that would help drive broad participation.

First, and most important, the minimum carbon price commitments would be tiered, acknowledging different levels of economic development (and indeed different degrees of responsibility for the underlying problem of climate change). Following Parry et al. (2021), we suggest three pricing tiers for lower-, middle-, and higher-income countries,

perhaps at €25, €50, and €75 (inflation indexed over time).<sup>24</sup> This tiered design is intended to give lower-income countries stronger incentive to join and to address concerns that CBAMs would otherwise disproportionately harm them. Tiering also offers flexibility for negotiation, with several clear levers to adjust, such as the price levels assigned to different countries, the duration of price discounts, and the speed of adjustments for free allowances and variations in cap-and-trade market designs.

Members would commit to minimum carbon prices that reflect their tier, and they would not face CBAMs from other member countries if they are pricing at their committed level. Countries would apply CBAMs to non-member countries. Whether they charge a lower tariff for lower-income non-member countries (or vary that discount) depends on how members weigh the desire to incentivise membership versus the desire to recognise differentiated responsibilities.

Whether poorer countries are in fact harmed by policies such as the EU CBAM is an empirical question. As the European Union removes the free allowances for EU producers and phases in the CBAM, EU prices for covered goods will rise, benefiting exporters who sell into Europe. At the same time, such sellers will face a tariff, potentially harming sellers.<sup>25</sup> For the cleanest producers, the price increase should dominate the tariff effect, and producer surplus will increase. For the dirtiest producers, the opposite is the case, and producer surplus may fall and/or producers may choose to divert their production to other non-CBAM markets, where prices are lower.

Whether poorer countries' producers gain or lose will depend on the emissions intensity of their production. Early evidence from Clausing et al. (2025) suggests that there is not a strong relationship between emissions intensity and GDP per capita, indicating heterogeneous effects on lower-income country producers. Still, there is ample concern about negative effects on poorer countries (Eicke et al., 2021; Magacho et al., 2023).

24 One could also include a fourth tier of exemption for the poorest countries without affecting many emissions; the 26 countries that the World Bank classifies as low-income generate 2.2% of world carbon emissions, and less than 1% of emissions in the CBAM industries. Still, several low-income countries have relatively clean production in the heavy industries and export the vast majority of their output, so they stand to gain fiscal revenues from imposing their own carbon price on heavy industries (Clausing et al., 2025).

25 In many cases, the incidence of a tariff falls on consumers in the market that levies the tariff, and the same would be expected in markets that implement CBAMs, such that European consumers (directly or indirectly) pay higher costs for steel, iron, aluminum, fertilizers, cement, and electricity in the case of the EU CBAM. The consumer burden from tariffs arises because world supply to any particular country is close to perfectly elastic, so the consumer side of the market bears the entire tax burden. In theory, large countries can drive down the world price of goods when they levy tariffs, by lowering worldwide demand for such goods and raising worldwide supply of such goods. In practice, these 'terms-of-trade effects' have not been observed in the multiple studies that have considered the case of recent US tariffs on Chinese goods (see Clausing and Lovely, 2024). Still, the larger the coalition that is levying such tariffs, the more likely it is to generate such terms-of-trade effects that harm exporters.

Our approach will help guard against such negative effects in multiple ways. Both a tiered pricing structure and the promise of uniform measurement, reporting, and verification standards will make joining a heavy industry climate coalition far more attractive than otherwise, hopefully encouraging broadly inclusive coalition membership. A larger coalition increases the effectiveness of the coalition by increasing its market size; non-members may seek to join the coalition in order to secure tariff-free access to the coalition markets.

Membership will also come with other benefits. For governments, industrial carbon pricing will generate domestic revenue that can be used for any fiscal need, including investing in mitigation or offsetting any household cost increases. Household costs are likely to be very minor for industrial carbon pricing, particularly for lower-income countries that export the bulk of their production, but they could be more significant for countries that implement broader carbon pricing.

The coalition could also induce broad participation with other desirable incentives. For instance, in clean energy production, access to key inputs (such as critical minerals) and technologies is often a pressing issue. In joining the coalition, countries could commit to barrier-free trade in clean energy inputs and enhanced sharing of technologies. With respect to trade, members could commit to forgo export restrictions (often weaponised in the past), to forgo tariffs on clean-energy inputs (except when needed to countervail subsidies, following WTO norms), and to avoid local content provisions.<sup>26</sup> Countries would together agree on a list of inputs to zero- or low-carbon production that would qualify for the liberalised regime. Technology sharing could be facilitated by the regular reporting of decarbonisation efforts in these industries, which would highlight progress, identify barriers, and facilitate coordination to accelerate technology transfer and innovation. Finally, member countries could work with the World Bank, the International Finance Corporation, and other large lenders to support clean technology investments in these industries.

Clean technology leaders, many of whom have traditionally been located in higher-income countries, would also benefit from these open access rules, and heavy industry in high-income countries would benefit from the reduced leakage concerns that a large coalition would entail. Global companies will benefit from a more uniform set of standards and procedures among coalition members. Most importantly, higher income countries would benefit from the policy momentum (discussed below) that the coalition approach promises.

26 Unfortunately, recent progress in the WTO has been slow, including on these issues. The Doha round failed to lower tariffs on environmental goods and services, or to achieve its other aims (Solleder and de Melo, 2019). Bown and Clausing (2024) suggest plurilateral reforms along the lines suggested in the text.

However, one shouldn't be excessively optimistic about the generosity of higher-income countries when setting the parameters of the coalition. Richer countries may be wary about providing lower pricing tiers for poorer countries, and commitments of climate finance and technical assistance, while highly desirable, can be difficult to muster in a world of pressing fiscal constraints. Thus, the precise parameters of these features of the coalition would certainly be subject to negotiation and innovation. For example, technology transfer could be done via partnership models between rich country and poorer country firms, which could help foster political support throughout (Gaikwad et al., 2025). This insight builds on earlier work on the domestic political economy of foreign aid which highlights that participating donor country firms can be important advocates of overseas engagement, while also including important roles for firm expertise in recipient countries (Milner and Tingley, 2015).

Still, well-off countries can be reassured that there would be provisions in place to 'graduate' countries when they become richer. In addition, it may be useful to sunset elements of the tiered preferences over time, perhaps alongside greater flows of climate finance and the earmarking of CBAM revenues toward a fund for mitigation and technical assistance for poorer countries.

Such steps could reassure governments of well-off countries that their firms would not be at a permanent disadvantage relative to those in poorer countries. Even though a temporarily lower carbon price would provide a competitiveness benefit for lower-income producers relative to EU producers, a plan to sunset would leave the long-run price signals aligned, reducing the incentive to migrate production out of EU markets. Further, EU firms' competitiveness in outside markets would be enhanced by the broader adoption of carbon pricing among coalition countries. Even if there were temporary leakage of emissions toward lower-income countries under tiered pricing, the emissions and competitiveness benefits associated with encouraging broader carbon price adoption are likely to dominate such effects, assuring that the proposal works in the long-term interest of global collective action around climate change.

Indeed, perhaps the largest benefit to all coalition members, and to the world, would be a genuine set of incentives to encourage bolder climate policy action. Indeed, as documented in Clausing et al. (2024), the early days of the EU CBAM have encouraged many governments to contemplate or implement new carbon pricing regimes, and media mentions of both carbon pricing and decarbonisation have surged accordingly. These incentives are particularly large for countries that are dependent on exporting carbon-intensive products to the European Union, as they have the most to gain from tariff free access to the EU market. Even the US public appears sensitive to the diffusion effects of CBAM (Ingles et al., 2024).

But the EU CBAM alone will provide less of a motivation for carbon pricing adoption than the plurilateral coalition we describe here. By folding its CBAM into a plurilateral effort, the European Union will avoid ill will abroad. While the tiered pricing structure will provide competitiveness advantages to lower-price countries, these advantages will be temporary, and they will act to help enlarge the coalition in a way that ultimately makes EU policies more sustainable.

While it is too early to say whether such policy momentum and diffusion will be long lasting, a heavy industry carbon coalition would be an excellent way to build on the carbon pricing momentum generated in part by the EU CBAM, and with time there would of course be room to expand the scope of the coalition, reaching other sectors of the economy beyond heavy industry.

Still, even a focus on heavy industry can reap large emissions reduction benefits. We estimate that the industries covered by the proposal account for about 20% of global carbon emissions. Using standard elasticities from the literature, we calculate that the heavy industry climate coalition has the potential to reduce worldwide emissions by 1.5%, or 570 mt per year, if the 17 G20 countries that presently employ some carbon pricing participate, or as much as 2.7%, or 1030 Mt, if participation covers the vast majority of the world.<sup>27</sup> Accounting for emission reductions in the electricity sector with the coverage of scope 2 emissions from the heavy industries could increase these estimates substantially.

The emissions reduction progress from a heavy industry climate coalition compares favourably to other benchmarks. For example, EU and US emissions in 2021 were 130 MT and 380 MT lower than they were in 2011, respectively.<sup>28</sup>

27 Appendix B discusses how we arrived at the global carbon emissions share and these estimates. We apply a carbon price semi-elasticity of -0.3% per \$1 t/CO<sub>2</sub> in 2023 US dollars. This is informed by estimates for carbon price semi-elasticities for aggregate emissions across economic sectors, which range from -0.02% to -0.52% per \$1 t/CO<sub>2</sub> in 2023 US dollars (Best et al., 2020; D'Arcangelo et al., 2022; Rafaty et al., 2021; Sen and Vollebergh, 2018). We assume a carbon price of \$50 per t/CO<sub>2</sub> in 2023 US dollars. For the G20 countries, we assume an average carbon price of \$10 per t/CO<sub>2</sub>, and thus estimate the reduction on an additional \$40 per t/CO<sub>2</sub> carbon price. For the rest of the world, we assume an average carbon price of \$5 per t/CO<sub>2</sub>, and thus estimate the reduction on an additional \$45 per t/CO<sub>2</sub> carbon price. We estimate that the G20 countries excluding Russia, the United States, and Saudi Arabia account for 62% of carbon emissions, based on Climate Watch 2021 data. We implicitly assume that the industrial share of emissions in these countries and the rest of the world are the same. Total 2022 carbon emissions are 38.5 Gt according to the Emissions Database for Global Atmospheric Research (Crippa et al., 2023).

28 Data based on Climate Watch. Of course, the challenges for these sectors to decarbonise are not uniform. Cement, for example, might be more challenging and costly. Nevertheless, our proposal helps to incentivise innovation that will reduce these costs.

## How would the heavy industry climate coalition be negotiated?

The year 2025 will be a delicate one for international cooperative efforts, to say the least. Disagreements surrounding Russia's invasion of Ukraine and conflicts in the Middle East have exacerbated underlying frictions, and relations between the world's two largest economies (and emitters) – the United States and China – are fragile, especially in the trade context. While both countries have invested heavily in clean energy technologies and capabilities, those efforts have also been in tension, as each seeks enhanced global competitiveness in these frontier industries.

Political events also imply challenges ahead. Under President Trump, the United States has stepped back from global climate leadership and has withdrawn from international collaborative efforts entirely. While most countries are quite unlikely to follow this lead, Argentina has seriously broached this possibility.<sup>29</sup>

The European Union could be a natural leader in this space, but recent European policy debates have revealed large differences among member nations in terms of energy policy, and governments in leading states are absorbed with boosting defence spending.<sup>30</sup> The situation of some key Asian partners is also politically fragile, with Korea facing a particularly challenging time<sup>31</sup> and Japan also facing political changes.<sup>32</sup> Canada and Mexico are especially vulnerable to the Trump administration's tariff policies, despite the recently renegotiated free trade agreement (USMCA). Canada, despite having a generally successful and well-designed carbon pricing regime, has also faced pushback on carbon pricing.<sup>33</sup>

It may therefore seem like a quixotic time to suggest increased international cooperation around climate. Still, several factors are reassuring. First, all negotiations take time, and technical and procedural progress can be made ahead of any ultimate political agreement. As one example, the international tax agreement came together swiftly in 2021, but only after years of convenings and a slow, arduous progress at the technical and bureaucratic levels of governance. Second, the salience of the climate change problem increases year after year in a dramatic fashion, so even recalcitrant governments may be willing to work on effective policy solutions. Third, politically volatile times can also create odd opportunities for progress. As just one example, while the Trump administration seeks to levy indiscriminate tariffs on most of the rest of the world, other governments may find it useful to explore areas of commonality where they can work collectively and isolate the United States while at the same time achieving broader climate policy goals. Fourth,

29 <https://www.batimes.com.ar/news/argentina/milei-says-hes-considering-taking-argentina-out-of-paris-agreement.phtml>

30 Still, Germany's recent constitutional amendment to allow higher government borrowing sets aside at least €100 billion for climate action.

31 <https://www.bbc.co.uk/news/articles/c878rjgv7d2o>

32 <https://www.bbc.co.uk/news/articles/c8xpev42g78o>

33 The current prime minister, Mark Carney, removed the consumer side carbon tax, but he remains committed to industrial carbon pricing and carbon border adjustments.

Brazil, a global leader in clean energy, will host the Conference of the Parties (COP) for the first time since the landmark 1992 Rio de Janeiro conference. This moment carries significant symbolic weight, presenting an opportunity for bold climate action and novel policy innovation and collaboration.

Finally, as noted above, both the EU CBAM and analogous efforts elsewhere (including in the United Kingdom) have helped spur new policy momentum around carbon pricing, and the vast majority of G20 jurisdictions (15, with two more in progress) have already enacted some form of carbon pricing.<sup>34</sup> China, meanwhile, which produces 50% of global steel and almost 60% of global aluminium, is expanding the scope of its carbon pricing program to cover three of the four heavy industry sectors (all but fertilizer).<sup>35</sup> By working together, countries forming a coalition can generate real incentives (both ‘sticks’ and ‘carrots’) that make cooperation easier by making it self-interested. Thus, one need not rely solely on international goodwill to make progress.

Our proposal is also naturally amenable to ‘dials’ that might facilitate negotiation. For example, the number of pricing tiers, and the gaps in prices between them, are both negotiable. Lower price tiers could be designed to slowly converge with higher price tiers, and countries hitting development benchmarks would ‘graduate’ to higher pricing tiers. The degree of climate finance, technical assistance, and dedicated revenues are all variables. Finally, the trade agreement component might help spur broad participation by providing joining countries with more security in their trading relationships, alongside greater market access. These factors can drive increased flows of trade and foreign direct investment while furthering the efficiency of the energy transition.

To enable greater participation in, and compliance with the terms of, a climate coalition, its design could leverage emerging institutions under the Paris Agreement. Article 6.2 of the Paris Agreement promotes various forms of bilateral cooperation to facilitate progress on countries’ NDCs. The linking of domestic cap-and-trade programmes serves as one approach consistent with Article 6.2 (Mehling et al., 2018).<sup>36</sup> Fully linking domestic cap-and-trade programmes with unfettered cross-border trade in emission allowances can both ensure common carbon prices among linked systems and obviate the need to report and verify carbon prices. Compliance with coalition membership could be determined by reporting comparable carbon prices or by fully linking domestic carbon pricing programmes.

34 India is expected to launch a domestic compliance carbon market by mid-2026 (see <https://icapcarbonaction.com/en/news/india-adopts-regulations-planned-compliance-carbon-market> and <https://carbon-pulse.com/365604>).

35 <https://carbonherald.com/china-expands-carbon-trading-market-to-heavy-industries-targeting-emissions-reduction>

36 For example, the EU ETS has formally linked with the Switzerland ETS, while Norway formally participates in the EU ETS. In both cases, Article 6.2 rules guide the accounting of flows in emission allowances (Hynes and Schneider, 2023). In the design of the CBAM, the EU exempts Switzerland and Norway (as well as Iceland and Liechtenstein, which also participate in the EU ETS) from the border adjustment mechanism.

Article 6.4 establishes the Paris Agreement Crediting Mechanism, which enables a firm or government to invest in a project in another country that reduces emission reductions. Emission offset credits could be sold to other firms or governments to demonstrate progress on emission reduction goals. The design of a climate coalition could account for such offset credits in a variety of ways (Aldy and Halem, 2024), but such policies need to be designed carefully; carbon pricing should apply to emissions broadly, not just to exported emissions, or reshuffling could undermine the goals of the policy.<sup>37</sup>

By designing the coalition consistent with Article 6 of the Paris Agreement, this initial plurilateral effort would establish a legitimate foundation for broadening access and participation in a more comprehensive, multilateral agreement down the road. It would also spur market-oriented strategies that could enhance cost effectiveness, strengthen economic ties, and promote political alignment among nations combating climate change.

There are also likely to be technical issues that need to be addressed, including how to ensure equivalence between pricing and emissions trading system (ETS) regimes, how to ensure the phase-out of free allowances under ETS regimes, how to pace and unify countries' pricing commitments in an environment where existing policies are heterogeneous, and how to support countries with lower administrative capacity.

During the negotiation window, delegates would meet to discuss all outstanding issues, some at the technical level and some at the political level. Once an agreement is reached, meetings would continue, refining implementation of the agreement, expansion of the agreement to new members or sectors, and handling other matters as they arise.

In our proposal, we do not specify either the leadership or the convening organisation for such an agreement. The former would depend in part on political developments among potential member states, and the latter may depend in part on the interests of those key leaders. The OECD facilitated the international tax agreement (alongside the G20 and a larger 'inclusive framework' that included a wide array of other jurisdictions). However, early political negotiations often involved a much smaller subset of jurisdictions, and China's "key partner" status at the OECD would need to be elevated to make serious progress on climate issues. Beyond the OECD and G20, we could also envision a role for the World Bank, the IMF, the UNFCCC, and other multilateral forums. However, the

37 Consider three design options. First, the certified emission reductions reflected in an offset credit could be used by a firm covered by the CBAM. Second, the price paid for offset credits could be used to reduce the border adjustment (e.g., the difference between the €75/t CO<sub>2</sub> price commitment and the offset credit price). Third, the expenditures for offset credit purchases (the product of offset price and the quantity of offset credits) could be used to reduce the total payments a firm must make to sell a good into the coalition (Sandler and Schrag, 2024). This could create another margin of compliance that could entice participation by more developing countries, although there are also political economy issues in richer countries. For example, firms covered by the EU ETS may want comparable access to international offset markets to demonstrate compliance with their ETS obligations if their foreign competitors can use offset markets to demonstrate CBAM compliance.

risk of beginning with a wide forum is that diffuse interests may make the initial push toward agreement more difficult. Thus, we find it most plausible to imagine progress through a ‘coalition of the willing’ among the G20 countries that presently have a carbon price.

## CONCLUDING THOUGHTS

What would a heavy industry climate coalition mean for the United States? In the short run, the US government would likely react to this development in either a neutral or unproductive fashion, perhaps threatening its own tariffs in response. While such a coalition would entail a well-justified and negotiated departure from nondiscriminatory WTO norms, outsider countries could even choose to cite the discriminatory nature of carbon levies (which would fall more heavily on high-income emitters) as a justification for retaliation.

However, the larger the coalition membership, the more futile such retaliation would prove. For example, if the vast majority of G20 jurisdictions that have an existing or contemplated carbon pricing regime all band together, they would cover nearly 60% of world GDP and more than 60% of world carbon emissions, and would include every major economy beyond the United States and two petrostates (Saudi Arabia and Russia).<sup>38</sup> That coalition would have substantial weight in the international community.

Further, with the system of sticks and carrots included in the heavy industry climate coalition, many jurisdictions throughout the world would have a strong incentive to join, potentially driving up membership to even higher shares of world emissions and GDP. Down the road, joining such a coalition could easily become an attractive option for future US administrations that are more focused on the problem of climate change.

At the start, the heavy industry climate coalition we envision would reach 20% of world greenhouse gas emissions, leading to an estimated 1.5% reduction in emissions. Progress in these sectors is important, particularly since the included industries are difficult to decarbonise. But in the end, the most important role of coalition would be to demonstrate how the use of incentives – both the enforcement mechanism of tariffs and the inducements of market access, freer trade in clean energy inputs, and climate finance – can help overcome longstanding and vexing global collective action problems.<sup>39</sup> As such, the coalition could become a stepping stone to larger climate policy efforts in the time ahead.

38 <https://www.imf.org/en/Publications/WEO/weo-database/2024/October/weo-report>

39 The use of an enforcement mechanism was also key to progress in the international tax agreement, in the form of an ‘undertaxed profits rule’ which allowed adopting countries to protect their tax bases from the profit shifting of companies based in non-adopting countries. That mechanism helped ensure adopting countries that non-adopters could not free ride on their efforts, degrading the value of the agreement.

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## APPENDIX A

This appendix describes how we reach the estimate that between 6% and 10% of US economic activity in heavy industries is or will be covered by a carbon pricing program.

### Overview of applicable cap-and-trade/emissions trading schemes

California, Oregon, and Washington all have some form of carbon pricing, cap-and-trade, or emissions trading programs that apply to energy intensive trade-exposed (EITE) industries. The programs are at different stages of implementation and have different specifications.

Of the three, California has the oldest such programme, having launched its cap-and-trade programme in 2013.<sup>40</sup> It covers sources that emit at least 25,000 metric tons of CO<sub>2</sub>-equivalent greenhouse gases a year. California allows for allowance trading, with the 2025 annual auction reserve price set at \$25.87 per CO<sub>2</sub>-equivalent of emissions.<sup>41</sup>

Oregon's Climate Protection Program has been reinstated starting 2025.<sup>42</sup> While it covers sources that emit at least 15,000 metric tons of CO<sub>2</sub>-equivalent greenhouse gases a year, EITE industries are only expected to face compliance obligations starting in the second compliance period, which will run from 2028 to 2029.<sup>43</sup> For EITE sources Oregon will issue 'compliance instruments' in the second compliance period, where each compliance instrument represents one ton of covered emissions. Each source is expected to receive compliance instruments that are equal to its average emissions from 2022 and 2023 multiplied by the emission reduction target. These instruments are tradable, and, additionally, EITE sources can meet up to 20% of their compliance obligation through Community Climate Investment Credits (CCIs), which are expected to be priced at \$129 as of 2025 (International Carbon Action Partnership, 2024b).

Washington's Cap-and-Invest programme, which started in 2023, applies to facilities or businesses that produce more than 25,000 metric tons of carbon emissions a year.<sup>44</sup> However, EITE industries are given no-cost allowances each year to cover most of their compliance costs until at least the end of 2034. For 2023-26, EITEs in Washington are given 100% no-cost allowances of baseline emissions, with allowances declining to 94% for 2031-34. Allowances in Washington's auction in March 2025 sold for \$50.<sup>45</sup>

40 <https://www.c2es.org/content/california-cap-and-trade/>

41 [https://ww2.arb.ca.gov/sites/default/files/2024-12/nc-2025\\_annual\\_reserve\\_price\\_notice\\_joint\\_auction.pdf](https://ww2.arb.ca.gov/sites/default/files/2024-12/nc-2025_annual_reserve_price_notice_joint_auction.pdf)

42 <https://oregoncapitalchronicle.com/2024/11/21/oregon-commission-approves-redo-of-landmark-climate-program-after-lawsuit-derailed-it/>

43 <https://olis.oregonlegislature.gov/liz/202311/Downloads/CommitteeMeetingDocument/287454> and <https://digitalcollections.library.oregon.gov/nodes/view/301548>

44 <https://ecology.wa.gov/air-climate/climate-commitment-act/cap-and-invest>

45 <https://washingtonstatestandard.com/2025/03/12/washington-carbon-auction-prices-rise-again/>

While free allowances are given (or are planned to be given, in the case of Oregon) in these programs, EITE sources still face a carbon incentive to reduce their emissions. As Washington's Department of Ecology notes: "Though EITEs receive no-cost allowances, they still have an incentive to lower emissions in the short-term if they're in a position to do so. This is because EITEs that emit fewer emissions than their allocation of no-cost allowances can save those allowances for future use, or they can sell them to other program participants".<sup>46</sup>

### **Share of heavy industries' activity covered by California, Oregon, and Washington**

We use releases from the 2022 Economic Census, which provides data at the state and industry (denoted by NAICS) levels on variables such as employment, total sales, and number of establishments.<sup>47</sup> To identify which NAICS industry codes to use, we look to analysis by Congressional Research Service (CRS) on Border Carbon Adjustments (Congressional Research Service, 2024). The CRS analysis of the Clean Competition Act, which is considered to be similar to EU's CBAM, identifies the following 6-digit NAICS codes which correspond close to our definition of heavy industries: 325311 (nitrogenous fertilizers), 327310 (cement), 331110 (iron and steel), 331313 (aluminium), and 331314 (aluminium) (Rasool et al., 2024; Congressional Research Service, 2024)

In an ideal world, for these five industry codes, we would look at the share of national economic activity (proxied by variables like sales or employment) covered by California, Oregon, and Washington. However, to preserve the confidentiality of respondents, the Economic Census suppresses data for certain cells if they span only a few establishments. Thus, we keep scaling up to the broader industry code until we have non-suppressed data for all three states:

- For 325311 (nitrogenous fertilizers), we use the broader 5-digit code 32531 (fertilizer and compost). The former granular industry code constituted about 50% of the latter's national sales.
- For 327310 (cement), we use the 4-digit code 3273 (cement and concrete product). The former granular industry code constituted about 15% of the latter's national sales.
- For 331110 (iron and steel), 331313 (aluminium), and 331314 (aluminium), we use the 3-digit code 331 (primary metal). The three granular industry codes account for about 44% of the code 331's total national sales.<sup>48</sup>

46 <https://ecology.wa.gov/air-climate/climate-commitment-act/cap-and-invest/emissions-intensive-trade-exposed-industries>

47 <https://www.census.gov/EconomicCensus>

48 Author's calculations, based on the Economic Census 2022.

For these three codes (32531, 3273, and 331) of US economic activity, we calculate the shares contributed to by these three states. Of the US sales, employment, and number of establishments in these three industry codes, we calculate the shares in the three states to be 6%, 9%, and 10%, respectively.<sup>49</sup>

## APPENDIX B

This appendix describes the sources for our estimate that the heavy industry climate coalition sectors account for 20% of global carbon emissions.

For carbon emissions from the four CBAM-affected manufacturing industries (steel and iron, cement, aluminium, and fertilizer), we use data from Bataille et al. (2024), which provides sector-level breakdowns of 2021 CO<sub>2</sub> emissions.

According to Bataille et al. (2024), the share of CO<sub>2</sub> emissions for the CBAM-affected manufacturing industries are 10.2% for steel and iron, 7.9% for cement and lime, 1.2% for ammonia production, and 0.5% for nonferrous metals, suggesting that about 19.8% of the world's CO<sub>2</sub> emissions are attributable to these four industries.

This value should be taken as an estimate since the definition of industries in Bataille et al. (2024) does not comport exactly with CBAM industries: for instance, CBAM only covers aluminium, but Bataille et al. (2024) use the value for nonferrous metals instead. Further, the values in Bataille et al. (2024) include all dedicated onsite CO<sub>2</sub> emissions, including for heat and power. These exclude emissions from utility electricity used for industrial processes, which account for a significant share of industrial emissions. While direct non-energy industrial emissions account for 26.8% of world carbon emissions, an additional 11.8% is attributed to utility electricity production for industry, resulting in 38.6% of carbon emissions being attributed to industrial processes.

Indeed, we find that the industry emission shares in Bataille et al. (2024) compare well for iron and steel, cement and lime, and ammonia, but less well for aluminium, which sources electricity largely from utilities. For instance, Kim et al. (2022) report that the iron and steel industry accounts for 7-9% of global emissions; Cheng et al. (2023) report that cement accounts for 5-8% of global emissions. McKinsey & Company (2023) and The Royal Society (2020) cite the share of carbon emissions from ammonia production as 1.2% and 1.8%, respectively. Estimates from the International Energy Agency suggest aluminium accounts for 270 Mt of CO<sub>2</sub> emissions in 2022,<sup>50</sup> which represents about 0.7% of global emissions. Factoring in indirect emissions, aluminium represents nearly 1 Gt of CO<sub>2</sub> emissions in 2022, implying an emissions share of 2.7%, well above Bataille et al. (2024)'s value for non-ferrous metals.

49 Author's calculations, based on the Economic Census 2022

50 <https://www.iea.org/energy-system/industry/aluminium>



# International climate finance as a win-win: The economic case for coalitions of disposed developed countries to fund decarbonisation in developing countries

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## 1 INTRODUCTION

The majority of 21st century emissions are projected to come from emerging and developing market economies (EMDEs). Even if developed countries decarbonise as they have promised to do and rapidly reach net zero, they will still be exposed to the effects of EMDE emissions if these countries do not embrace decarbonisation at scale and speed up their energy transition. Under current policies, the world is projected to face a dangerous rise in average temperatures above pre-industrial levels of between 2.8°C and 3.1°C by the end of the century (UNEP, 2024), whilst climate science finds that the Paris Agreement goal of 1.5°C is a critical limit not to exceed: every extra 0.1°C beyond this limit significantly increases tipping point risk and the occurrence of extreme climate events.

In this chapter, we examine the economic case for coalitions of self-interested advanced countries to provide climate finance at scale to those developing countries that commit to decarbonising their power sectors and cannot pay for the energy transition themselves, building on earlier research by Bolton et al. (2024), who examined the economic case for an advanced country coalition to pay for the phase-out of coal in EMDEs. Here, we broaden the analysis to the replacement of all fossil fuel power sources rather than just coal.

1 We thank Yuktha Bhadane, Rudy Tanin, Fhrad Panahov and Heejin Han for their excellent research assistance. We also thank Jeromin Zettelmeyer, Tobias Adrian, Ottmar Edenhofer and Johan Rockström, who have contributed to the research underpinning this chapter. We further thank Jean-Pisani Ferry, Beatrice Weder di Mauro and Jeromin Zettelmeyer for their valuable feedback on the chapter.

Climate finance is rooted in climate agreements. The 1992 United Nations Framework Convention on Climate Change (UNFCCC) climate agreement classified countries into “developing” (non-Annex I) and “developed” (Annex II). Based on this classification and on the principle of “common but differentiated responsibilities” (CBDR) formed at the 1992 UNFCCC, developed countries have been expected to take the lead in reaching net zero. The CBDR principle also led to the pledge by developed countries to provide \$100 billion of climate finance per year by 2020 to help developing countries decarbonise and adapt to climate change. This pledge was part of the COP21 Paris Agreement in 2015 under Article 9 about climate finance:

“In accordance with Article 9, paragraph 3, of the Agreement, the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement shall, *before 2025*, set a **new collective quantified goal from a floor of USD 100 billion per year**, *taking into account the needs and priorities of developing countries*”

The good news is that an agreement on climate finance was reached at COP29 in 2024, referred to as the “New Common Quantified Goal” (NCQG), as planned. However, as we show here, the agreed amount was too little, too late, and of too low-quality climate finance.

Indeed, the agreement reached at COP29 was that “developed country Parties taking the lead, [would] provide at least USD 300 billion per year by 2035 for developing country Parties for climate action from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources in the context of meaningful and ambitious mitigation and adaptation action”. Article 7 of the NCQG [agreement text](#)<sup>2</sup> additionally “calls on all actors to work together to enable the scaling up of financing to developing country Parties for climate action from all public and private sources to at least USD 1.3 trillion per year by 2035”.<sup>3</sup>

Following COP29, in a joint statement with leading climate scientists and climate finance academics<sup>4</sup> we explained how this goal falls short of what is needed to limit global warming to 1.5°C. The NCQG goal is too late, because the climate finance should have been made available by 2025 not 2035; it is too little, because no pure public climate finance commitment by developed countries has yet been made; and it is of too low-quality, because no definition is agreed on what counts as public climate finance. Only

2 <https://unfccc.int/documents/643641>

3 Whilst developed countries were keen to expand the contributor base of climate finance - by including countries (such as China) that are still classified as “developing” according to the UNFCCC agreement, but have grown wealthy enough to support their own transition and contribute to that of others - ultimately a reclassification of developed and developing countries did not get unanimous buy-in. Instead, the NCQG agreement *encourages* developing country Parties to make contributions [to climate finance], including through South-South cooperation, on a voluntary basis.

4 <https://e-axes.org/research/joint-statement-on-the-new-common-quantified-goal-ncqg-of-climate-finance-and-its-delivery-on-the-1-5c-paris-agreement-goal-addressed-to-all-states-party-to-the-convention-mr-simon-stiell/>

grants or equivalents should count, not market-based or concessional loans accounted for at their notational value, as is currently done. Notional loans, even at concessionary rates, add to developing countries' debt burdens and fail to provide the catalytic and early closure grant-equivalent funds needed.

As we argue in Bolton et al. (2025), a key reason why climate finance is not forthcoming in time is that it has not been explicitly tied to emissions reductions in developing countries. We show that the provision of climate finance from developed to developing countries is in the economic interest of developed countries, whenever they can tie it to emissions reductions in developing countries. Their economic benefits from the provision of climate finance – in terms of avoided climate damages and adaptation costs to themselves – exceed the cost of climate finance provision. Moreover, we show that climate finance at scale is also fiscally affordable to developed countries.

It has proved impossible to reach an agreement that explicitly ties financing to decarbonisation, partly because of opposition from oil-producing countries. To be able to move forward, therefore, an agreement has to be sought that does not necessarily include all parties – an agreement between disposed developed countries and developing countries following the lines of Nordhaus' general idea of climate clubs (Nordhaus, 2015; 2020). The countries in the European Union, in effect, are setting up a climate club with the European Emissions Trading System (EU ETS) the introduction of the Carbon Border Adjustment Mechanism (CBAM).

Carbon taxes – a stick-based approach – make fossil fuels (and related goods) more expensive. Climate finance – a carrot-based approach – makes renewables cheaper. In a world where only 28% of global greenhouse gases (GHGs) are taxed,<sup>5</sup> according to the World Bank, and the average global net carbon price is \$4/tCO<sub>2</sub> according to the Kepos Carbon Barometer,<sup>6</sup> the provision of climate finance plays an important complementary role to the woefully inadequate levels of carbon taxation.

In this chapter, we propose an approach based on the formation of 'climate finance coalitions' of self-interested, disposed developed countries that collectively fund renewable energy development in those developing countries that commit to decarbonisation. Climate finance coalitions and climate carbon clubs work harmoniously together. To the extent that carbon border taxes make exports by developing countries to climate club countries more expensive, climate finance provision – in grant-equivalent form – helps them switch to renewables, essentially for free. Climate – finance and carbon – clubs, if implemented along-side each other, thus provide a double incentive, at the requisite speed and scale, for global decarbonisation.

Our approach is guided by the following economic principles that together underpin the cost-effective financing of EMDE decarbonisation:

5 <https://carbonpricingdashboard.worldbank.org/compliance/coverage>

6 <https://www.carbonbarometer.com/policy-overview>

1. A ton of avoided CO<sub>2</sub> yields the same global benefit, no matter where it is reduced. Accordingly, developed countries should support emissions reductions where abatement is cheapest – often in EMDEs – so long as the economic benefits to them exceed the cost.
2. Decarbonisation should be structured at the jurisdictional level through coordinated pipelines: one for phasing out fossil fuel plants and one for phasing in renewable capacity. A system-wide approach enhances cost-efficiency, increases predictability for investors, and reduces the risk of carbon leakage.
3. Climate finance needs to cover both the phase-out cost (the opportunity cost of retiring fossil fuel plants early) and the cost of investments required to cover the growing share of demand unmet by phased-out coal and other fossil fuels. The latter should take into account the projected increase in energy demand.
4. Public finance is an essential component of climate finance, both because the opportunity costs of phasing out fossil fuels cannot be covered by private finance and because the costs of capital are often (still) too high in many countries, relative to the profitability of renewables investment, to make the phase-in pipeline commercially viable. Hence, some public subsidy may be necessary to crowd in private investment. We assume that public finance must cover 100% of fossil fuel phase-out costs, and 25% of renewable investments – a benchmark that may range from below 10% to above 25%, depending on country-specific risk profiles.
5. To the extent that the public portion – delivered as grants or equity – is covered by external funding (such as by a climate finance coalition advocated in this chapter), it should be disbursed conditionally, based on avoided emissions (through the implementation of the phase-in and phase-out pipeline) or other implementation milestones. The authority to disburse the public funds on a conditional basis could be given to an agency (or committee) representing developed donor countries and multilateral development banks (MDBs), playing a role similar to that of the IMF when granting emergency funding to countries in financial distress. This agency – call it the International Climate Fund (ICF) – would enter into a ‘programme’ agreement with an EMDE (possibly based on a country platform), specifying the conditional financing and implementation.

In what follows, we report our baseline empirical estimates – and underpinning data and methodology – of climate finance needs to decarbonise developing market economies in Section 2. We evaluate the economic case for distinct coalitions of self-interested, disposed developed countries to finance decarbonisation in various sets of recipient developing countries in Section 3. Section 4 lays out policy considerations. We then conclude.

## 2 THE COSTS OF DECARBONISING THE POWER SECTOR IN DEVELOPING COUNTRIES

This section reproduces cost estimates for decarbonising the power sector in developing countries, based on Bolton and Kleinnijenhuis (2025). The basis for the estimates is a dataset by Forward Analytics that contains plant-level data on all power sector assets (fossil fuels and renewables) and their relevant characteristics (capacity, emission intensity, ownership, etc.). Country-level estimates can be calculated through the following steps:

1. Project energy demand and associated emissions under current policies ('business as usual'), based on each country's current energy mix.
2. Calculate the emissions pathway the country would need to follow to implement 1.5°C-aligned decarbonisation ('net zero').
3. Determine the *phase-out pipeline*: which fossil fuel assets must be phased out when to implement the carbon budget-aligned net-zero pathway of emissions established in Step 2.
4. Estimate the *cost of the phase-out pipeline* (i.e., the opportunity cost of phasing out fossil fuels) as the expected missing cash flows to fossil fuel plants from closing early, plus retraining costs, plus wage compensation at prevailing wages for five years. The latter is taken as a proxy for the costs that might be incurred until workers in the fossil fuel sector find employment in new sectors.
5. Determine the *phase-in pipeline*: how much renewable capacity of what type (wind and solar) must be phased in, when, and where (including also energy storage capacity and grid extension) to replace fossil fuel capacity and keep up with any growth in energy demand. In our baseline estimates, we assume that each country chooses a mix of renewables to phase in (i.e., phase-in weights) equal to their current renewable energy mix (we check this does not exceed land availability).
6. Estimate the *cost of the phase-in pipeline* by taking current investment costs in each renewable type, storage capacity and grid expansion, and projecting how these may fall in the future as a function of learning-by-doing effects. We model the latter using the empirically calculated 'Wright's law' (i.e., assuming that the unit cost of renewable energy declines exponentially as a function of cumulative global deployment).

Table 1 reports an extract of our country-level estimates (see Appendix Table A1 for the full information). The left set of columns show the *investment costs* of implementing the phase-in pipeline, while the middle set shows the *opportunity costs*. The right set shows the total, both for the entire 11-year period of 2024-2035 and per year, with the last

column giving a crude estimate of the annual fiscal costs of transition. We assume that public climate finance must cover 100% of the opportunity costs of fossil fuels, as it does not generate a revenue stream and alternatives are not reliable, but only cover 25% of the renewables investment costs, with the rest covered by private finance.<sup>7</sup>

The results can be summarised as follows:

1. The total cost of the power sector transition to net zero in developing countries, including China, over the next 11 years is about \$9.7 trillion, or \$883 billion per year. Excluding China, the total cost drops to about \$5.1 trillion, or \$464 billion per year. About 77% of this corresponds to the cost of building new wind and solar plants; 12% to creating electricity storage (batteries), 8% to grid expansion, and just 2.3% to the opportunity costs of closing fossil fuel plants early. Most of the latter is for worker compensation and retraining. The reason that the opportunity costs for owners are relatively low is that our calculation does not try to cover the opportunity costs of not burning remaining coal, oil, and gas reserves, merely compensate owners for the early retirement of fossil fuel plants, many of which are already close to the end of their productive age.
2. Costs vary greatly by country, depending on economic size and current energy mix. Reflecting the size of its power sector, the cost of power sector transition in China is the highest (\$4.6 trillion, of which \$4.5 trillion is renewables investment and the rest opportunity costs). The next most expensive power sector to decarbonise is India's, with \$1.1 trillion in renewable investment cost and \$26 billion in opportunity costs.
3. Including China, the total average annual fiscal cost of power sector transition is in the order of \$238 billion per year between 2025 and 2035. If China is excluded, this falls to \$124 billion per year. If we were to include *all* countries listed as developing in the Annex to UNFCCC (1992), some of which now may be high-income – including China, but also South Korea, Saudi Arabia, and some other gulf states which are excluded from Table 1 (see table note) – then the total annual fiscal cost would rise to \$256 billion per year.

7 The IEA and IFC (2023) estimate that, with some public 'de-risking' (on average, about \$1 dollar in donor finance for \$10 in private finance), about 80% of the energy transition costs could be privately funded. This implies an overall public sector share of around 25-30%.

**TABLE 1 COST OF 1.5°C-ALIGNED DECARBONISATION OF THE POWER SECTOR IN SELECTED DEVELOPING COUNTRIES, 2024-2035 (US\$ BILLION)**

Country	Renewables investment costs (RC)				Opportunity costs (OC)				Total climate finance need		
	Total RC	Renewable energy sources	Storage	Grid extension and other	Total OC	Owners	Workers	Total need, 2024-2035	Total need, annual	Annual fiscal cost (25% RC + 100% OC)	
China	4602.20	4498.70	583.10	425.20	103.47	0.00	103.47	4602.20	418.38	114.00	
India	1141.25	1115.55	164.21	115.48	25.70	1.06	24.64	1141.25	103.75	28.27	
Iran	409.66	365.10	28.58	15.98	6.75	2.62	4.13	416.41	37.86	9.92	
Egypt	404.57	344.46	31.20	28.91	0.39	0.16	0.24	404.97	36.82	9.23	
Indonesia	338.71	268.17	44.52	26.01	5.35	2.26	3.09	344.06	31.28	8.18	
Iraq	298.25	268.33	18.75	11.17	7.05	1.77	5.28	305.30	27.76	7.42	
Mexico	237.80	189.83	28.12	19.77	6.89	5.55	1.34	244.69	22.25	6.03	
Viet Nam	220.81	166.34	31.15	23.32	5.53	0.45	5.08	226.34	20.58	5.52	
South Africa	212.73	158.11	32.25	22.37	5.26	0.02	5.24	217.98	19.82	5.31	
Thailand	192.43	160.18	19.68	12.58	1.72	0.03	1.70	194.16	17.65	4.53	
Brazil	153.44	115.50	23.11	14.82	15.61	12.47	3.14	169.05	15.37	4.91	
Malaysia	138.26	108.71	17.61	11.93	2.31	0.95	1.35	140.57	12.78	3.35	
Bangladesh	116.61	82.75	19.95	13.91	5.99	0.90	5.09	122.60	11.15	3.20	
Nigeria	78.79	67.06	7.88	3.86	0.63	0.04	0.60	79.43	7.22	1.85	
Pakistan	75.71	54.84	12.65	8.22	2.80	0.27	2.53	78.51	7.14	1.98	
Algeria	76.22	62.80	7.80	5.61	0.44	0.04	0.40	76.66	6.97	1.77	
Kazakhstan	74.84	57.28	10.03	7.54	1.12	0.19	0.93	75.96	6.91	1.80	
Argentina	72.17	54.92	10.44	6.81	0.52	0.03	0.49	72.69	6.61	1.69	
Philippines	68.39	51.24	10.15	7.00	2.73	0.25	2.48	71.12	6.47	1.80	
Other developing	706.22	538.78	102.40	65.04	22.83	6.11	16.71	729.06	66.28	18.13	
Developing inc. China	9593.37	8448.97	1203.65	845.55	223.09	35.16	187.92	9712.99	882.10	238.31	
Developing exc. China	4991.17	3950.27	620.55	420.35	119.62	35.16	84.45	5110.79	464.62	124.31	

Note: "Developing countries" refers to set defined by UNFCCC (1992), excluding Bahrain, Brunei Darussalam, Kuwait, Qatar, Saudi Arabia, South Korea and United Arab Emirates. "Storage" refers to the sum of short-term and long-term storage, "Grid extension and other" to the sum of Grid extension and Renewables to power electrolyzers (see Table A1). "Workers" to the sum of workers' 5-year wages and workers' retraining. See notes to Table A1.

Source: Bolton and Kleijnijenhuis (2025).

### 3 THE NET BENEFITS OF FUNDING DECARBONISATION IN EMDEs

This section estimates the net benefit of funding the power sector decarbonisation of developing countries for various groups of advanced countries (referred to as ‘climate finance coalitions’ or ‘financier coalitions’ below). We obtain these with the following steps.<sup>8</sup>

1. For each developing country, we compute cumulative avoided emissions associated with the power sector transition as the cumulative difference between country-level emissions under business-as-usual and the carbon budget-aligned net-zero scenarios for the power sector (the same that were used in the cost estimates above).
2. *Global* benefits are computed by multiplying these country-level cumulative avoided emissions by an estimate of the global social cost of carbon (SCC). We use two estimates that together represent a reasonable range: \$190/tCO<sub>2</sub> (Biden administration estimate; Rennert et al., 2022) and \$1056/tCO<sub>2</sub> (in line with Bilal and Känzig, 2024).
3. *Country-level* benefits of avoided emissions are obtained by multiplying the global avoided emissions benefit computed in step 2 with each country’s share in the SCC, using country-level SCC shares estimated by Ricke et al. (2018). For example, the estimated SCC share of the United States is 29%, the shares of the European Union and China are about 11.2% each, India 6.5%, and Japan 2.8%. The SCC share of all advanced (developed) countries as defined in UNFCCC (1992), Annex II, is 48%.
4. Finally, we compute net benefits as the difference between fiscal costs (i.e., the public part of the climate finance need) and benefits for the financier coalition, on the assumption that the financier coalition pays the entire fiscal cost of the power sector transition. In Bolton et al. (2024), we show how the net benefits would differ if each developing country contributes to the fiscal cost to the full extent of its private benefit in terms of avoided emissions. Taking these private benefits into account makes a big difference for China in India – because of their large share in the global SCC – but a much smaller difference for the remaining recipient countries. In this chapter, we disregard this aspect.

In the remainder of this section, we first compare the costs and benefits of fiscal support for power sector decarbonisation in developing countries from the perspective of a group of advanced financier countries. Our baseline case is that *developed countries* (those classified as Annex II countries under the 1992 UNFCCC agreement) provide climate finance to *developing countries* (those classified as non-Annex I countries under the

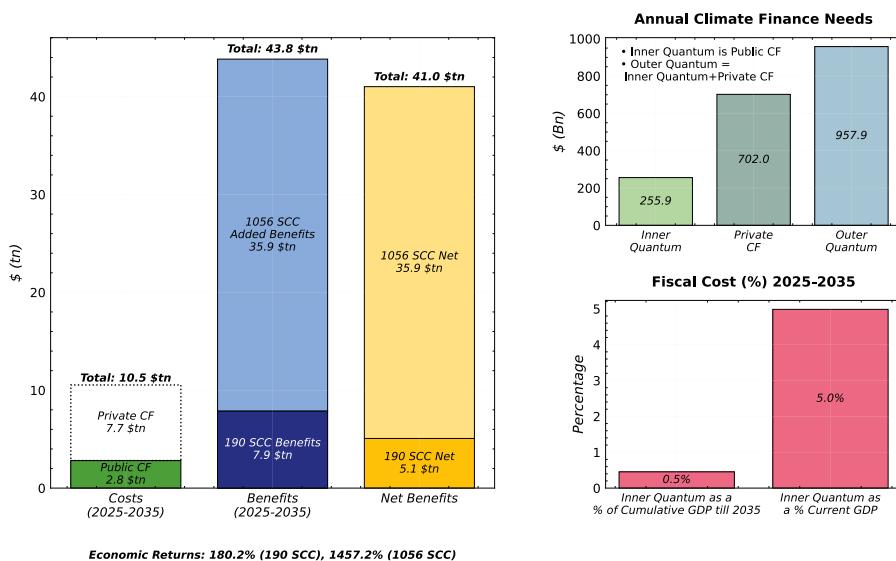
8 For more details on the methodology, data, and conceptual foundation see Adrian et al. (2022), Bolton et al. (2024) and Bolton and Kleinnijenhuis (2025).

1992 UNFCCC agreement). In addition, we examine the politically more realistic case in which the recipient group excludes China and the countries that have become high income in the meantime, while the financier group excludes the United States. We next examine net benefits of decarbonising power in a group of specific developing countries.

### 3.1 Net benefits of funding the energy transition of developing countries as a group

Figure 1 examines the case in which all developed countries as a group subsidise the energy transition of all developing countries as a group. The left plot compares the costs of decarbonising all developing countries in the 1992 definition (including both fiscal costs and the portion that can be covered by private finance, left bar) with the economic benefits of decarbonisation for developed countries. The main result is that the benefits to developed countries as a group greatly exceed the fiscal costs of \$2.8 trillion. Even if the lower SCC of \$190/tCO<sub>2</sub> is assumed, the financier coalition would enjoy a ‘profit’ of over \$5 trillion.

**FIGURE 1 COSTS AND BENEFITS TO DEVELOPED COUNTRIES (UNFCCC ANNEX II) OF FINANCING 1.5°C-ALIGNED TRANSITIONS IN DEVELOPING COUNTRIES (UNFCCC NON-ANNEX I)**



Note: the left bar of the left plot shows the total costs (outer perimeter) and fiscal cost (green box) of decarbonising the power sector of all developing countries in the definition of UNFCCC (1992), non-Annex I. This corresponds to all countries covered by Table 1, plus Bahrain, Brunei Darussalam, Kuwait, Qatar, Saudi Arabia, South Korea, and United Arab Emirates. The middle bar of the left panel shows the benefits of funding this decarbonisation to the developed countries in the definition of UNFCCC (1992), with an assumed SCC share of 48%, (Ricke et al., 2018), based on the assumption that the global SCC is either \$190/tCO<sub>2</sub> (Biden administration estimate; Rennert et al., 2022) or \$1056/tCO<sub>2</sub> (in line with Bilal and Känzig, 2024). The top-right plot splits annual climate finance into the annual “inner quantum” of public climate finance which must be offered in grant-equivalent terms (fiscal costs), and the “outer quantum” of total climate finance including mobilized private climate finance. The bottom-left plot shows the fiscal affordability to financier countries. The left bar shows the total 2025-2035 fiscal cost to financier countries as a percentage of the financier countries’ 2025-2035 cumulative GDP. The right bar shows the total 2025-2035 public climate finance costs to financier countries (as shown in bottom-stack part of left bar of the left plot) expressed as a percentage of financier countries’ 2024 GDP. The latter estimates by how much sovereign debt of financier countries would rise as a percentage of their GDP if they would pay for the 2025-2035 climate finance fully at the beginning, in 2024, by issuing sovereign debt.

Source: Bolton and Kleijnjehuis (2025).

The upper-right plot expresses fiscal costs (i.e., public climate finance; left bar) and private finance costs (middle bar) in annual average terms; the right bar (“outer quantum”) is the sum of the two. The latter (\$958 billion) is broadly consistent with the \$1 trillion that Bhattacharya et al. (2024) estimate developing countries need by 2030. In our calculations, however, this need arises immediately (in 2025) rather than by 2030 (as the High-Level Expert Group on Climate Finance, or HLEG, recommends) if the goal is to implement Paris-aligned Nationally Determined Contributions (NDCs) in 2025 and for the world to stay within the 1.5°C carbon budget.

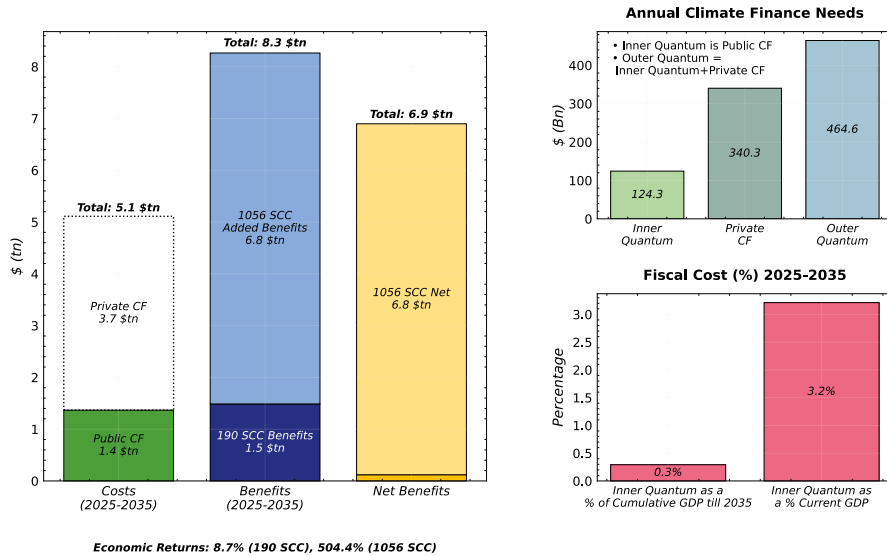
Finally, the lower-right plot shows that the fiscal costs of funding developing country energy transition are moderate as a share of GDP of the financier countries, at 0.5% of total GDP over the same time period, or 5% of GDP if the entire fiscal cost 2025-2035 is expressed as a percentage of 2024 annual GDP.

While useful as a benchmark, the case shown in Figure 1 is unrealistic in the sense that both the financier and the recipient groups are too broad. The latter includes all developed countries including the United States, which would not participate in any international climate funding at least for the duration of the present administration, while the latter includes China and several countries that are now considered high-income.

Figure 2 shows how the results change if these are eliminated from the recipient group and the financier group now consists only of the G7 excluding the United States, the remaining EU countries, Norway, Switzerland, Australia, and South Korea. The elimination of China and the oil-producing countries from the recipient group has a dramatic impact on costs, with total costs falling from \$10.5 trillion to \$5.1 trillion, while fiscal costs fall from \$2.8 trillion to \$1.4 trillion (left plot, left bar). But since the GDP of the financier group is smaller, fiscal costs as a share of GDP do not fall as dramatically – from 0.5% of GDP to 0.3%, or from 5% percent of GDP to 3.2% if the entire 2024-25 fiscal cost is expressed as a share of 2024 GDP (bottom-right plot). The main result is that net benefits for the financier coalition remain positive, even at the relatively low SCC of \$190/tCO<sub>2</sub>, although the financier coalition is now much smaller, with an SCC share of only around 21% based on Ricke et al. (2018), and although the avoided emissions financed by this coalition are not as high (because China, South Korea, and several oil producers are excluded).

In summary, Figure 2 shows that even if the United States does not join the developed countries coalition, it is still in the economic interest of the European Union and other coalition members to provide climate finance at the needed scale to those developing countries that need it and commit to credible decarbonisation. It is also fiscally affordable to them, at 0.3% of their GDP.

**FIGURE 2 COSTS AND BENEFITS FOR FINANCIER COALITION (CONSISTING OF G7 EXCL. US, EU, SOUTH KOREA, NORWAY, SWITZERLAND, AND AUSTRALIA) OF FINANCING 1.5°C-ALIGNED TRANSITIONS IN DEVELOPING COUNTRIES (EXCLUDING CHINA, PETRO-RICH STATES, AND SOUTH KOREA)**

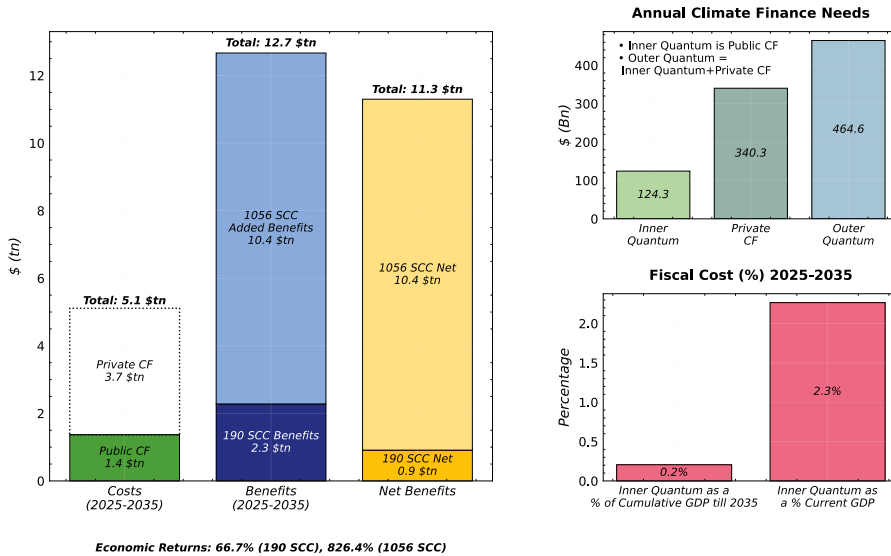


Note: See note to Figure 1.

Source: Bolton and Kleijnjehuis (2025).

The final variation of the financier coalition we consider is one where China joins the European Union and allies in the provision of climate finance. China is well positioned to support developing countries in their decarbonisation efforts. By joining the climate finance financier coalition, it stands to also benefit from exporting its renewables to countries in the Global South, as they receive climate finance to install these as part of their phase-in pipeline. In Figure 3, we show that if China joins the financier coalition, the total climate finance *need* for all developing countries remains, logically, unchanged. What does change is that the fiscal cost to the financier coalition falls from 0.3% of their annual GDP to 0.2% of their annual GDP. In addition, the gross and net benefits to the financiers increase by about \$800 billion, assuming a low SCC of \$190/tCO<sub>2</sub>, and by about \$4.4 trillion if a high SCC of \$1056/tCO<sub>2</sub> is assumed, as the economic benefits to China – whose SCC share is approximately as large as that of the European Union, at 11.3% according to Ricke et al. (2018) – are now included.

**FIGURE 3 COSTS AND BENEFITS TO FINANCIER COALITION (CONSISTING OF G7 EXCL. US, EU, CHINA, SOUTH KOREA, NORWAY, SWITZERLAND, AUSTRALIA) OF FINANCING 1.5°C-ALIGNED TRANSITIONS IN DEVELOPING COUNTRIES (EXCL. CHINA, PETRO-RICH STATES, AND SOUTH KOREA)**



Note: See note to Figure 1.

Source: Bolton and Kleinnijenhuis (2025).

### 3.2 Net benefits of funding the energy transition of individual developing countries

Figure 2 shows that the net benefits of funding the energy transition of developing countries are positive, and likely large, even for a relatively small financier coalition. However, this result might be hiding large differences in the economic returns to power sector decarbonisation across recipient countries. Given constraints to fiscal and implementation capacity, it makes sense to prioritise the recipients with the highest benefits.

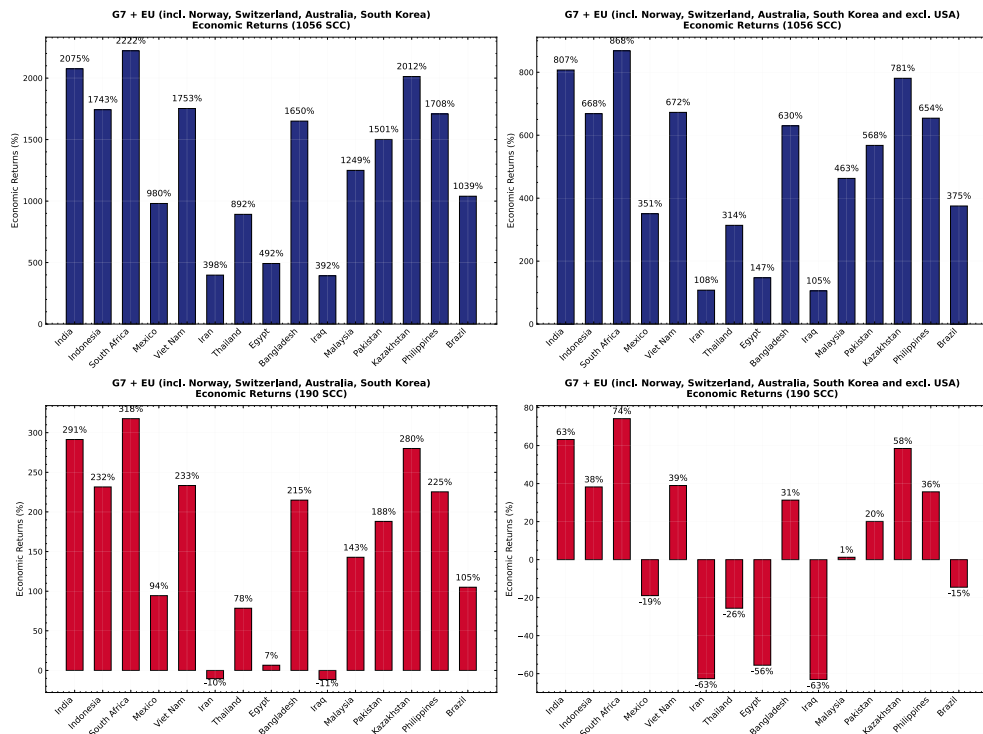
To see whether this is the case, Figure 4 reports country-level estimates of net returns (benefits minus costs, divided by costs) for the 15 largest developing country power sector emitters. The results cover two assumed financing coalitions: the G7 including the United States, the European Union, China, South Korea, Norway, Switzerland and Australia (left column); and the same coalition, but excluding the United States (right column). The upper row reports results for an assumed global SCC of \$1056/tCO<sub>2</sub>, while the lower row assumes an SCC of \$190/tCO<sub>2</sub>.

The main finding is that there are large differences in economic returns arising from power sector decarbonisation across the 15 countries, with Iran, Iraq, and Egypt showing the lowest returns, and India, South Africa, and Kazakhstan the highest. While all returns are positive for the high assumed SCC of \$1056/tCO<sub>2</sub>, returns for Iraq and Iran

turn negative when the SCC of \$190/tCO<sub>2</sub> is assumed, even if the United States is part of the climate finance coalition (bottom-left plot). If the United States does not contribute and an SCC of \$190/tCO<sub>2</sub> is assumed, the economic returns for the finance coalition for Mexico, Egypt, Iraq, and Iran turn negative.

The main reason why the economic return of decarbonising the power sector of countries such as Mexico, Egypt, Iraq, and Iran is lower than that of countries such as India, Indonesia, and South Africa is that the latter rely on coal, the most CO<sub>2</sub>-intensive fuel. That said, the global economic return to decarbonising even the oil- and gas-based power sectors remains high, and a large financial contribution to their decarbonisation would make sense even for the narrower climate finance club, if it can be complemented by additional donors or by a domestic public or private effort (including through greater use of carbon pricing).

**FIGURE 4 ECONOMIC RETURN TO FINANCIER COALITIONS (CONSISTING OF G7, EU, SOUTH KOREA, NORWAY, SWITZERLAND, AND AUSTRALIA) FROM FINANCING 1.5°C-ALIGNED MITIGATION IN TOP 15 DEVELOPING COUNTRY POWER SECTOR EMITTERS (IN PERCENT)**



Note: Economic return is defined as mitigation benefits to the financier coalition minus fiscal costs of decarbonisation in percent of fiscal costs. Left plots include the United States in the finance coalition, right plots exclude it. Top plots assume SCC of \$1056/tCO<sub>2</sub>; bottom plots assume \$190/tCO<sub>2</sub>.

Source: Bolton and Kleijnjehuis (2025).

Table 2 reports the average annual climate finance costs of decarbonising the power sectors of the top 15 developing country power sector emitters over 2025-2035. Total costs are broken down into what the public sector must cover (fiscal costs) and what the crowded-in private sector can cover (annual private climate finance). We again assume that developed countries cover 25% of investment costs in renewables (and complementary technologies) and 100% of fossil fuel early closure costs. The fiscal cost to the financier coalition (irrespective of whether the United States contributes) is very small and would be even smaller as a percentage of their annual GDP. Financing decarbonisation of individual developing countries is thus fiscally affordable to developed countries, while generating a large economic return in most cases (see Figure 4).

**TABLE 2 COSTS OF MEETING 1.5°C-ALIGNED MITIGATION NEEDS IN TOP 15 DEVELOPING COUNTRIES BY POWER SECTOR EMISSIONS**

Country	Climate finance costs		Annual fiscal costs (percent of 2024 GDP)	
	Annual fiscal costs (\$ billion)	Annual private climate finance (\$ billion)	G7 + EU (incl. Norway, Switzerland, Australia, South Korea)	G7 + EU (incl. Norway, Switzerland, Australia, South Korea and excl. USA)
India	27.7	76.0	0.04	0.07
Indonesia	8.2	23.1	0.01	0.02
South Africa	5.3	14.5	0.01	0.01
Mexico	6.0	16.2	0.01	0.01
Viet Nam	5.5	15.1	0.01	0.01
Iran	9.9	27.9	0.01	0.02
Thailand	4.5	13.1	0.01	0.01
Egypt	9.2	27.6	0.01	0.02
Bangladesh	3.2	78.0	0.00	0.01
Iraq	7.4	20.3	0.01	0.02
Malaysia	3.4	9.4	0.00	0.01
Pakistan	2.0	5.2	0.00	0.00
Kazakhstan	1.8	5.1	0.00	0.00
Philippines	1.8	4.7	0.00	0.00
Brazil	4.9	10.5	0.01	0.01

## 4 POLICY CONSIDERATIONS

It is important to keep in mind that the public funding is likely to come from a subset of high- and middle-income countries that benefit from EMDE decarbonisation and that are volunteering to cooperate in channelling climate finance at scale to EMDEs. Some countries that have the financial wherewithal may not participate, most notably the United States, and these countries therefore should not have any control rights over how this funding is allocated. Accordingly, a legal entity or vehicle separate from existing international financial institutions – we will call it the International Climate Fund (ICF) – will have to be set up, which will be governed by the funding countries joining the EMDE climate finance coalition.

As even the most willing countries joining this coalition will only be able to contribute limited funds (and revenues from carbon levies in one form or another, or raising sovereign debt, will also be limited), a fundamental objective ought to be to maximise the amount of EMDE decarbonisation that can be funded per dollar available of public funds channelled to the ICF. This means that financing the decarbonisation of EMDEs must rely on multiple funding sources – public, non-profit, and for-profit – with the objective of maximising the fraction of private funding from capital markets that can be attracted.

Maximising the quantity of decarbonisation per dollar, in turn, requires that the governance of phased-in renewable energy investment and the phase-out of fossil fuel operations offers the strongest possible protections to investors and the lowest costs. This is best achieved through a jurisdiction-level approach (rather than project-level), where the recipient country commits to a joint phase-in and phase-out pipeline of projects (through country platforms or other mechanisms).<sup>9</sup> Another key advantage of a jurisdiction-level approach is that it ensures that there will be no carbon leakage. Indeed, a key weakness of a project-level approach is that there is no guarantee that the early closure of a fossil fuel power plant will not be followed by, or accompanied by, another fossil fuel-based facility. In effect, the ICF would enter into a climate finance programme with a recipient country, whereby funding for the next period – from both public and private sources – is conditional on meeting pre-agreed decarbonisation milestones along the jurisdiction-

9 A jurisdiction-level approach is essential to enable a speed and scale transition. No fossil fuel power plant will be closed unless there is a concrete plan for what renewable capacity to build in its place – otherwise, the country risks energy insecurity. Likewise, no renewable plant can be added unless there is a coordinated plan for how to connect it to the grid and supply it with sufficient storage. A jurisdiction-level approach is also critical for advance planning. When a country needs to close dozens – or, in the case of large emitters like China or India, even over a hundred – fossil fuel power plants each year to remain aligned with a net-zero carbon budget, this can only be achieved through detailed, forward-looking coordination. Renewable projects must be planned in advance to come online at the right time as replacements. This approach is also necessary to obtain permitting rights for the phase-in pipeline in advance, and to set enabling legislation (such as the German Coal Phase-Out Act of 2020) that clears legal and institutional bottlenecks. Any supporting infrastructure or grid upgrades likewise require synchronised planning. Finally, a jurisdiction-level strategy is essential to mobilize funding at the scale truly required for a country's transition to net zero. In short, only the jurisdiction-level approach allows for cohesive, advance planning at the speed and scale required to heed the climate science and timely resolve the climate crisis.

wide decarbonisation pathway. These funds would support the next phase-in pipeline of renewables and the phase-out pipeline of fossil fuels. For example, continued funding could depend on the country having achieved the previous period's *avoided emissions* target necessary to stay aligned with a 1.5°C-compatible decarbonisation pathway.

A major constraint that both the ICF and EMDE countries are likely to face is expertise in infrastructure investment and renewable energy investments. This expertise often resides in development banks. Accordingly, the creation of the ICF is best structured in partnership with a consortium of MDBs (and possibly national development banks). There are obviously different ways this partnership could be structured, and there are several leading MDB candidates that could partner with the ICF.

Note that the funding towards the decarbonisation of EMDEs would not be channelled directly to MDBs for two basic reasons. First, most MDBs are restricted in the types of investments they can make (for example, they cannot make equity investments) and their mission is primarily development finance, which is much broader than financing the energy transition. Second, the shareholder base of most MDBs is much larger than the group of countries that are likely to be willing to join a climate finance coalition.

Another important practical consideration is that private investor participation will not be forthcoming unless the risks and the transaction costs are sufficiently low. Two important implications follow from this observation.

First, to sufficiently de-risk renewable energy investments for private investors, the public funding (from the ICF and possibly other sources) would take the form of a first-loss (equity) tranche, set at a level sufficient to attract private capital. De-risking can also be achieved through other blended finance instruments, such as power purchase agreements (PPAs) and guarantees. However, because these instruments offer no upside to the guarantor by design, they can be more costly from a public finance perspective. The risk exposure of the public (first-loss) tranche can be further reduced by granting property and commercial development rights as collateral, thereby allowing public investors to capture some of the spillover value created by the renewable energy investments. Another way of derisking EMDE debt issuance to fund renewable energy investments could be to set up a credit default swap (CDS) insurance platform, where sovereign wealth funds and other long-term investors would be sellers of CDS protection.

Second, to sufficiently lower the transaction costs for private sector investors, who are likely to be mostly 'plug and play' investors, the project preparation and permitting would be done by the ICF and the relevant (MDB) partners, in cooperation with government entities in the jurisdictions receiving funding from the ICF (and possibly also infrastructure development companies). There could also be implementation partners.

## 5 CONCLUSION

This chapter provides granular estimates of the costs and benefits of 1.5°C-compatible decarbonisation of the power sectors in developing countries. These estimates inform the negotiations finalising the new climate finance agreement at COP30, as well as ongoing negotiations among coalitions of disposed developed and developing countries outside the COP framework. Indeed, a key insight of our analysis is that the absence of a global consensus, which has led to watered-down COP agreements on climate finance in the past, and in the face of retreat by the United States from climate mitigation, meaningful climate action and climate finance is not only possible, but also in the interest of a smaller coalition of disposed developed countries (which could also include China) and of those recipient developing countries that commit to a 1.5°C-compatible decarbonisation pathway. Our analysis shows that a coalition of disposed, self-interested developed countries – including, potentially, China – can economically justify and fiscally support the timely provision of climate finance at the scale needed to decarbonise the power sectors of all developing countries.

On the recipient side, developing countries that commit to decarbonisation plans – jurisdiction-wide pipelines of fossil fuel phase-outs and renewable phase-ins – can position themselves to access the necessary external climate finance to implement transitions aligned with a 1.5°C-consistent trajectory. This is a win for developing countries: it enhances their sustainable development prospects, reduces air pollution, lowers adaptation costs, and helps avert escalating climate disasters. It enables them to transition to clean energy at reasonable cost, while safeguarding national habitability.

On the financier side, we show that it is in the direct economic interest of sufficiently large coalitions of disposed developed countries to provide at scale climate finance in grant-equivalent terms when this climate finance is explicitly tied to measurable emissions reductions in the developing countries committing to decarbonisation. This is a win for developed countries: financing the cheapest mitigation opportunities abroad lowers the overall costs of abatement and reduces their exposure to escalating climate damages and adaptation costs at home, with returns that far exceed the investment. There is no plausible path to a global net-zero target without supporting decarbonisation in developing countries, which are otherwise projected to emit the majority of 21st-century GHGs.

The climate financing approach we propose – jurisdiction-wide, conditional, and coalition-based – is a coherent climate finance solution. Conceptually, the climate finance coalition (“climate finance club”) we outline parallels the “climate [carbon] club” idea of Nordhaus: a (non-global) coalition of self-interested, disposed countries leading decarbonisation. Unlike carbon clubs, the climate finance coalition works through carrots rather than sticks – which may have greater appeal in the developing world. Yet, a combination of carbon club and climate finance coalition – a combination of carrots

and sticks – is likely to deliver the most effective way forward for the decarbonisation of developing economies. In a world where carbon pricing remains sparse and insufficient, international climate finance provides the complementary mechanism needed to deliver decarbonisation at speed and scale.

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**TABLE A1 COSTS AND CLIMATE FINANCE NEED ASSOCIATED WITH 1.5°C-ALIGNED DECARBONISATION OF THE POWER SECTOR IN DEVELOPING COUNTRIES, 2024-2035 (US\$ BILLION)**

Country	Total climate finance need	Renewables investment costs (RC)						Opportunity costs (OC)			
		Total RC	Renewable energy sources	Short-term storage	Long-term storage	Renewables to power electrolyzers	Grid extension	Total OC	Owners	Workers 5 year wages	Workers retraining
Total including China	9712.994	9489.871	7440.669	1063.453	140.197	166.574	678.974	223.086	35.16	184.314	3.608
Total excluding China	5110.794	4991.171	3950.269	547.753	72.797	73.974	346.374	119.617	35.16	82.839	1.615
China	4602.200	4498.700	3490.400	515.700	67.400	92.600	332.600	103.469	0.000	101.475	1.993
India	1141.254	1115.553	835.864	144.964	19.245	21.953	93.527	25.7	1.061	24.165	0.475
Iran	416.406	409.659	365.095	25.174	3.405	0.873	15.111	6.748	2.617	4.05	0.08
Egypt	404.967	404.574	344.463	27.601	3.603	12.238	16.668	0.393	0.155	0.233	0.005
Indonesia	344.055	338.706	268.173	39.359	5.164	0.746	25.264	5.349	2.255	3.034	0.06
Iraq	305.303	298.252	268.333	16.613	2.133	0	11.173	7.051	1.767	5.184	0.1
Mexico	244.692	237.804	189.833	24.926	3.271	4.731	15.042	6.888	5.55	1.312	0.026
Viet Nam	226.342	220.812	166.343	27.593	3.552	5.153	18.17	5.53	0.451	4.981	0.098
South Africa	217.984	212.729	158.112	28.464	3.786	3.623	18.743	5.256	0.016	5.138	0.101
Thailand	194.155	192.432	160.175	17.355	2.32	2.589	9.994	1.723	0.026	1.664	0.033
Brazil	169.05	153.437	115.503	20.436	2.676	2.214	12.608	15.613	12.474	3.078	0.061
Malaysia	140.565	138.259	108.714	15.567	2.044	1.716	10.218	2.307	0.953	1.328	0.026
Bangladesh	122.6	116.61	82.748	17.642	2.311	2.429	11.481	5.99	0.902	4.991	0.097
Nigeria	79.428	78.794	67.058	6.937	0.938	0.075	3.786	0.633	0.036	0.585	0.012
Pakistan	78.507	75.705	54.836	11.11	1.539	0.734	7.487	2.802	0.271	2.483	0.048
Algeria	76.662	76.218	62.804	6.897	0.904	1.26	4.352	0.443	0.04	0.396	0.008
Kazakhstan	75.961	74.842	57.277	8.847	1.178	1.634	5.906	1.119	0.194	0.908	0.018
Argentina	72.688	72.171	54.918	9.245	1.198	1.04	5.77	0.517	0.03	0.477	0.009
Philippines	71.12	68.39	51.238	8.747	1.406	1.172	5.827	2.73	0.252	2.43	0.047
Syrian Arab Republic	54.216	52.794	45.058	4.302	0.544	0.091	2.799	1.422	0.455	0.949	0.018
Uzbekistan	49.407	48.263	36.304	6.36	0.909	0.432	4.257	1.144	0.526	0.607	0.012
Ghana	43.228	43.088	32.582	5.701	0.745	0.556	3.504	0.14	0.038	0.1	0.002
Morocco	42.551	42.233	34.812	3.869	0.508	0.488	2.555	0.319	0.035	0.279	0.006

Country	Total climate finance need	Renewables investment costs (RC)					Opportunity costs (OC)				
		Total RC	Renewable energy sources	Short-term storage	Long-term storage	Renewables to power electrolyzers	Grid extension	Total OC	Owners	Workers 5 year wages	Workers retraining
Chile	41.461	40.38	28.927	6.191	0.823	0.701	3.737	1.081	0.176	0.888	0.017
Turkmenistan	41.081	40.442	31.768	4.563	0.608	0.778	2.725	0.639	0.474	0.162	0.003
Israel	38.893	38.007	26.511	5.986	0.778	0.765	3.968	0.886	0.017	0.852	0.017
Colombia	30.619	29.581	22.434	3.706	0.485	0.643	2.312	1.039	0.751	0.281	0.006
Libya	27.83	27.121	18.466	4.671	0.614	0.567	2.803	0.709	0.028	0.668	0.013
Azerbaijan	25.284	24.818	20.841	2.056	0.286	0.228	1.407	0.466	0.231	0.231	0.005
Oman	25.134	24.26	17.843	3.893	0.494	0.574	1.456	0.875	0.042	0.817	0.016
Peru	21.281	21.039	15.74	2.904	0.396	0.38	1.618	0.242	0.155	0.085	0.002
Serbia	19.491	19.186	13.695	2.708	0.374	0.495	1.914	0.305	0.04	0.26	0.005
Venezuela, Bolivarian Republic of	19.485	18.367	13.792	2.633	0.343	0	1.599	1.118	0.726	0.384	0.008
Singapore	17.458	16.716	11.132	2.943	0.416	0.349	1.876	0.741	0.328	0.405	0.008
Dominican Republic	15.293	14.674	10.857	2.025	0.275	0.273	1.243	0.62	0.348	0.267	0.005
Tunisia	15.159	15.029	10.262	2.527	0.327	0.328	1.586	0.129	0.015	0.113	0.002
Lebanon	13.062	12.428	10.776	0.97	0.134	0	0.548	0.633	0.068	0.555	0.011
Zimbabwe	11.242	9.829	7.112	1.431	0.186	0.218	0.882	1.413	0	1.386	0.027
Jordan	10.272	9.782	6.257	1.844	0.242	0.203	1.236	0.49	0.181	0.303	0.006
Yemen	10.105	9.847	7.849	1.072	0.149	0.182	0.595	0.259	0.094	0.161	0.003
South Sudan	9.378	8.681	6.959	0.975	0.131	0.003	0.613	0.696	0.011	0.673	0.012
Democratic People's Republic of Korea	8.929	8.814	7.372	0.809	0.105	0	0.529	0.115	0.006	0.108	0.002
Trinidad and Tobago	7.888	7.577	5.84	0.898	0.117	0.152	0.569	0.311	0.257	0.054	0.001
Bosnia and Herzegovina	7.601	7.383	6.207	0.81	0.133	0.013	0.22	0.219	0	0.214	0.004
Sri Lanka	7.275	6.901	5.596	0.693	0.101	0.078	0.432	0.374	0.041	0.327	0.006
Lao People's Democratic Republic	7.206	6.864	5.151	0.961	0.125	0	0.628	0.342	0.007	0.329	0.006
Myanmar	6.714	5.587	4.32	0.701	0.096	0.021	0.449	1.126	0.001	1.104	0.021

Country	Total climate finance need	Renewables investment costs (RC)						Opportunity costs (OC)			
		Total RC	Renewable energy sources	Short-term storage	Long-term storage	Renewables to power electrolyzers	Grid extension	Total OC	Owners	Workers 5 year wages	Workers retraining
Cambodia	6.217	5.903	4.584	0.658	0.118	0.097	0.446	0.315	0.007	0.302	0.006
El Salvador	6.142	6.08	4.73	0.716	0.095	0.117	0.423	0.062	0.015	0.046	0.001
Cuba	5.948	5.815	4.12	0.879	0.12	0.131	0.564	0.133	0	0	0
United Republic of Tanzania	5.736	5.728	4.758	0.589	0.082	0	0.298	0.008	0.006	0.002	0
Bolivia (Plurinational State of)	5.232	4.953	3.508	0.754	0.103	0.092	0.496	0.278	0.219	0.058	0.001
Panama	4.771	4.596	3.457	0.598	0.079	0.09	0.372	0.174	0.095	0.078	0.001
Honduras	4.613	4.449	3.313	0.618	0.081	0.055	0.382	0.163	0.077	0.085	0.001
Montenegro	4.308	4.237	3.485	0.386	0.048	0.068	0.25	0.07	0	0.069	0.001
Republic of Moldova	4.048	3.89	2.565	0.722	0.101	0.078	0.424	0.158	0.117	0.04	0.001
Senegal	3.942	3.898	2.827	0.588	0.084	0.084	0.315	0.045	0.003	0.041	0.001
Angola	3.805	3.794	3.099	0.411	0.058	0.017	0.209	0.011	0.003	0.008	0
Jamaica	3.644	3.595	2.806	0.386	0.05	0.091	0.262	0.049	0.01	0.039	0
Botswana	3.523	2.945	2.227	0.381	0.048	0.06	0.229	0.578	0	0.566	0.011
Ecuador	3.282	3.224	2.571	0.379	0.052	0.003	0.219	0.058	0.054	0.004	0
Guatemala	3.029	2.958	2.273	0.377	0.051	0.036	0.222	0.07	0.019	0.05	0.001
Uruguay	2.971	2.889	2.278	0.338	0.052	0.062	0.159	0.082	0.068	0.014	0
Kyrgyzstan	2.889	2.83	2.205	0.357	0.045	0	0.223	0.06	0.002	0.056	0.001
Cameroon	2.419	2.408	1.834	0.338	0.046	0	0.19	0.011	0.003	0.008	0
North Macedonia	2.272	2.185	1.956	0.148	0.022	0.014	0.045	0.087	0.012	0.073	0.001
Mongolia	1.849	1.479	1.479	0	0	0	0	0.37	0.002	0.361	0.007
Zambia	1.83	1.668	1.288	0.225	0.032	0.006	0.117	0.162	0.001	0.158	0.003
Gabon	1.772	1.759	1.309	0.251	0.032	0	0.168	0.013	0.001	0.011	0
Armenia	1.67	1.58	1.58	0	0	0	0	0.09	0.016	0.073	0.001
Georgia	1.555	1.48	1.199	0.153	0.025	0.001	0.101	0.075	0.017	0.057	0.001
Kenya	1.442	0.998	0.65	0.182	0.026	0.018	0.122	0.444	0.001	0.434	0.008
Mauritania	1.331	1.112	0.728	0.205	0.028	0.023	0.129	0.218	0.113	0.104	0.002

Country	Total climate finance need	Renewables investment costs (RC)						Opportunity costs (OC)			
		Total RC	Renewable energy sources	Short-term storage	Long-term storage	Renewables to power electrolyzers	Grid extension	Total OC	Owners	Workers 5 year wages	Workers retraining
Nicaragua	1.19	1.124	0.82	0.162	0.022	0.014	0.105	0.066	0.019	0.047	0.001
Bahamas	1.06	0.986	0.77	0.113	0.015	0.019	0.069	0.074	0.013	0.06	0.001
Mauritius	0.744	0.709	0.481	0.137	0.021	0.015	0.054	0.035	0	0.034	0.001
Mozambique	0.716	0.666	0.491	0.099	0.015	0.008	0.053	0.05	0.001	0.048	0.001
Tajikistan	0.69	0.62	0.477	0.079	0.01	0	0.053	0.069	0.005	0.063	0.001
Madagascar	0.676	0.594	0.41	0.1	0.013	0.009	0.063	0.082	0.001	0.079	0.001
Mali	0.56	0.559	0.446	0.062	0.008	0.007	0.036	0.001	0.001	0	0
Congo	0.512	0.49	0.378	0.076	0.011	0	0.024	0.022	0	0.021	0
Equatorial Guinea	0.481	0.435	0.349	0.048	0.007	0	0.031	0.046	0	0.045	0.001
Burkina Faso	0.46	0.388	0.266	0.066	0.009	0.008	0.04	0.071	0.001	0.069	0.001
Djibouti	0.44	0.372	0.291	0.043	0.006	0.007	0.026	0.068	0.001	0.066	0.001
Chad	0.393	0.329	0.257	0.038	0.005	0.006	0.023	0.064	0.001	0.062	0.001
Sierra Leone	0.388	0.318	0.209	0.059	0.008	0.006	0.036	0.07	0.001	0.067	0.001
Uganda	0.383	0.27	0.193	0.042	0.006	0.001	0.028	0.112	0.001	0.11	0.002
Somalia	0.268	0.24	0.157	0.045	0.006	0.005	0.027	0.028	0.001	0.027	0.001
Niger	0.26	0.115	0.115	0	0	0	0	0.145	0	0.142	0.003
Barbados	0.244	0.226	0.148	0.042	0.006	0.005	0.026	0.018	0.005	0.013	0
Papua New Guinea	0.218	0.218	0.159	0.033	0.005	0	0.022	0	0	0	0
Antigua and Barbuda	0.207	0.199	0.149	0.025	0.004	0.004	0.017	0.008	0.007	0.001	0
Benin	0.199	0.193	0.154	0.02	0.003	0.005	0.011	0.006	0	0.005	0
Seychelles	0.194	0.169	0.111	0.031	0.004	0.003	0.019	0.025	0	0.024	0
Afghanistan	0.18	0.174	0.146	0.015	0.002	0.001	0.01	0.006	0.002	0.004	0
Maldives	0.142	0.139	0.104	0.018	0.002	0.003	0.012	0.003	0.002	0.001	0
Suriname	0.127	0.11	0.08	0.023	0.005	0	0.002	0.017	0.002	0.015	0
Eritrea	0.116	0.049	0.049	0	0	0	0	0.067	0	0.066	0.001
Togo	0.112	0.112	0.087	0.015	0.002	0.002	0.006	0	0	0	0
Rwanda	0.107	0.105	0.066	0.02	0.003	0.002	0.014	0.002	0	0.002	0

Country	Total climate finance need	Renewables investment costs (RC)					Opportunity costs (OC)				
		Total RC	Renewable energy sources	Short-term storage	Long-term storage	Renewables to power electrolyzers	Grid extension	Total OC	Owners	Workers 5 year wages	Workers retraining
Costa Rica	0.092	0.08	0.06	0.011	0.002	0.001	0.007	0.012	0.001	0.011	0
Central African Republic	0.061	0.039	0.026	0.007	0.001	0.001	0.004	0.021	0	0.021	0
Namibia	0.052	0.052	0.041	0.006	0.001	0.001	0.004	0	0	0	0

Notes: Column 3 reports the climate finance needs for each developing country as defined by UNFCCC 1992 non-Annex I, excluding Bahrain, Brunei Darussalam, Kuwait, Qatar, Saudi Arabia, South Korea and United Arab Emirates, to implement 1.5°C-aligned NDCs over 2025-2035. Renewable investment costs consist of replacing fossil fuels and keeping up with growth in energy demand, short-term energy storage via lithium-ion batteries (in line with Way et al. (2022)), we conservatively assume that 20 percent of daily generated renewable energy must be able to be stored short-term); long-term energy storage via green hydrogen produced with electrolyzers (in line with Way et al. (2022)) we conservatively assume that one month worth of annual generated renewable energy must be able to be stored long-term; renewables to power electrolyzers so that the hydrogen produced is green; and grid extension. The opportunity costs consist of the opportunity costs of: the expected discounted missed free cash flow from early closure, i.e. the stranded asset value for owners; fossil fuel worker lost wages for the duration of 5 years; and fossil fuel worker retraining for employment elsewhere, particularly in the renewable industry. For 45 countries, estimates are not available due to data limitations. Detailed methodology is presented in Section 9.5 of Bolton and Kleinmijenhuis (2024).

Source: Bolton and Kleinmijenhuis (2025).



# Reconciling the European Union's clean industrialisation goals with those of the Global South

Ben McWilliams,<sup>a</sup> Simone Tagliapietra,<sup>a</sup> and Jeromin Zettelmeyer<sup>ab1</sup>

<sup>a</sup>Bruegel; <sup>b</sup>CEPR

## 1 INTRODUCTION

Can the growth strategies of the European Union and developing countries be made consistent with each other and with decarbonisation? On the face of it, the answer appears to be no.

The European Union wants to boost production from green energy-intensive industries and increase domestic manufacturing of clean technologies needed for the energy transition to 40% of consumption by 2030.<sup>2</sup> The European Commission's February 2025 Clean Industrial Deal (European Commission, 2025a), building on Draghi (2024), seeks to reconcile decarbonisation and industrial strength by "*lowering energy prices, creating high quality jobs and the right conditions for companies to thrive*".<sup>3</sup> An accompanying Affordable Energy Action Plan (European Commission, 2025b) seeks to ensure cheap green energy for European manufacturing industries.<sup>4</sup>

But expanding green manufacturing and retaining or expanding heavy industry in decarbonised form is exactly the growth model successfully pursued by China in the last decade. Many developing countries want to emulate this, including India, which wishes to raise its share of manufacturing in value added (see Chapter 11 by Partha Sen).

This disconnect poses a significant problem, for two reasons. First, growth strategies that seek to promote the same set of green industrial jobs tend to result in subsidy races and/or trade conflict. This is already happening with the Trump administration's tariff wars, which are motivated by the desire to reshore industrial jobs. While the EU has

1 We thank Roel Dom, Heather Grabbe, Jean Pisani Ferry and Beatrice Weder di Mauro for comments on an earlier draft.

2 In the EU Net-Zero Industry Act (Regulation (EU) 2024/1735).

3 "Clean Industrial Deal", European Commission ([https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal\\_en](https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_en)).

4 See [https://energy.ec.europa.eu/strategy/affordable-energy\\_en](https://energy.ec.europa.eu/strategy/affordable-energy_en).

taken more measured steps – by, for example, imposing countervailing duties on Chinese electric vehicles and putting in place a carbon border adjustment mechanism, both of which are arguably consistent with World Trade Organisation rules – even these are viewed as protectionist by China and by countries such as India (see Chapter 11).

Second, inconsistent national industrial development plans imply that proposed strategies for international decarbonisation may be politically unfeasible. For example, a major expansion of international climate finance, funded by a coalition of advanced countries can be shown to be in the economic interests of the coalition, as measured by the coalition's share of the avoided global social cost of carbon (Bolton et al., 2024; see also Chapter 5 by Patrick Bolton and Alissa Kleinnijenhuis). But fiscal transfers in support of green growth in the South will hardly be politically feasible if viewed as threatening the industrial growth ambitions in the financier countries.

A reverse problem arises in Deese's (2024) proposal for a "Clean Energy Marshall Plan" in which advanced countries would offer massive financial support for emissions reduction in the South, in exchange for raw materials to support green industrialisation in the North. This brand of global decarbonisation is likely to be rejected by developing countries that wish to reduce dependency and raise their manufacturing shares.

This chapter argues that European and developing country industrialisation ambitions can nevertheless be made consistent, for a simple reason: Europe is energy poor, leading to high energy costs. While costs may fall as zero-emissions energy sources are expanded, energy in Europe will remain expensive relative to other regions, particularly developing countries with much richer endowments of wind, hydro, and solar energy. Green energy trade will not equalise these energy cost differences because electricity and hydrogen are expensive to transport.

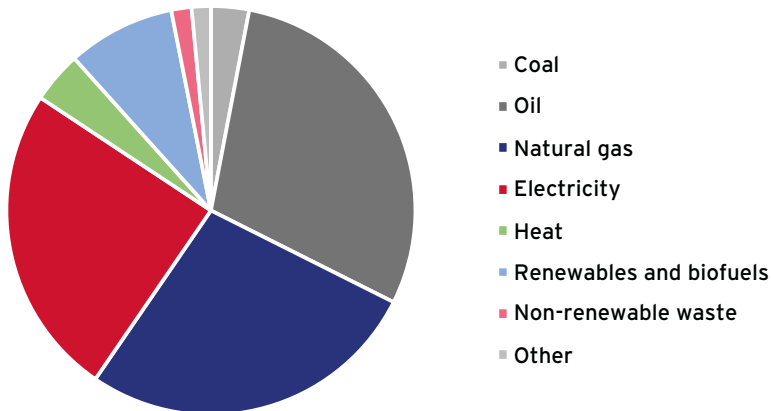
This suggests an international division of labour in which the South specialises in green production of energy-intensive intermediate inputs, such as ammonia and reduced iron ore, while the EU imports these inputs as a cheaper alternative to direct energy imports. While the EU will have lost the value added and jobs associated with these inputs, these amount to only a small fraction of overall industrial value added – and the resulting reduction in energy demand in Europe will help make the rest of industrial production competitive.

The remainder of this chapter proceeds as follows. In Section 2, we identify a green industrialisation strategy that maximises EU competitiveness, focusing on the question of how Europe can overcome its relative energy shortage at least cost. In Section 3, we explain how this strategy can be made consistent with the (green) industrialisation ambitions of the Global South. Finally, in Section 4, we discuss EU policies – domestically, and with respect to international trade and investment partnerships – that would implement the strategy.

## 2 GREEN INDUSTRIALISATION IN THE EUROPEAN UNION

Two-thirds of the energy products consumed by European industry come from oil products, natural gas, and coal (Figure 1).<sup>5</sup> There is little extraction of fossil fuels in Europe, so almost all of these energy products are imported. Green European industrialisation involves substituting these imports for new industrial processes powered by green energy. Europe's future industrial competitiveness will depend on the price of this green energy.

FIGURE 1 INDUSTRIAL DEMAND FOR ENERGY COMMODITIES, EUROPEAN UNION, 2023



Source: Bruegel based on Eurostat.

We define green energy as electricity produced without burning fossil fuels, and chemical fuels derived from electricity (such as hydrogen). In principle, the European Union has three ways to meet its demand for green energy: domestic production, direct imports (in the form of electricity or green hydrogen), and imports of green energy embedded in highly energy-intensive tradeable inputs, such as ammonia and direct reduced iron ore (DRI).

Industrial strategies in Europe rely on these three approaches to varying degrees. The European Commission's strategy, including the Clean Industrial Deal, is focused mostly on domestic production, particularly after the 2022 Russian invasion of Ukraine and the ensuing energy crisis illustrated the dangers of dependence on imported energy sources. Modelling from the European Commission (2024) on achieving climate neutrality in 2050 sees negligible volumes of direct electricity imports and overall energy import dependency falling dramatically. However, non-electricity energy imports would continue to play a role at EU level, particularly for energy value chains involving hydrogen, a focus of the

5 2,000 TWh out of a total 3,300 TWh demand across energy and non-energy uses.

European Union's 2020 hydrogen strategy (European Commission, 2020). At the level of EU member states, hydrogen imports play a disproportionate role in Germany, where the government hydrogen strategy foresees hydrogen imports accounting for 50% to 70% of total domestic hydrogen demand.

The idea that it might make sense to import energy in the form of intermediate products has received less political attention – perhaps because it requires accepting the principle that Europe might need to offshore at least some energy-intensive production traditionally done in Europe. However, the energy price hikes of 2022 have already prompted the offshoring of some particularly energy-intensive intermediate products, such as ammonia. Furthermore, both Germany's hydrogen strategy and the European Union's RePowerEU (issued after Russia's invasion of Ukraine to wean the EU off Russian energy imports) plan include hydrogen derivatives (such as ammonia) in hydrogen imports (BMWK, 2023; European Commission, 2022).

In the rest of this section, we argue that if European industry is to maintain or regain its competitiveness, imports of energy-intensive intermediate inputs will need to play a much greater role than currently recognised. Sections 2.1 and 2.2 make the *prima-facie* efficiency case. Relative to other world regions, Europe's clean energy endowments are poor and thus some degree of energy imports is efficient. Intermediate products are much cheaper to import than energy directly.

Sections 2.3 and 2.4 evaluate the economic costs and benefits for European industry of offshoring energy-intensive production stages. Costs include the direct loss of value added and potential adverse spillovers on the rest of the economy. Benefits would include lower input costs, boosting the competitiveness of the energy-intensive production stages that would remain in Europe, and lower industrial energy demand and hence energy prices, benefiting all European energy consumers – including industrial customers.

Finally, Section 2.5 briefly evaluates the potential effects on economic security. These depend on the counterfactual (whether the alternative to increased offshoring of intermediate inputs is greater reliance on domestic energy or higher direct energy imports), and on how offshoring is managed.

## **2.1 Europe's green energy endowments are relatively poor**

The European Union needs much more green energy. In 2023, the bloc produced 1,810 TWh of clean electricity.<sup>6</sup> Modelling by the European Commission (2024) suggests that 6,300 TWh to 7,000 TWh of clean electricity will be required by 2050 to reach net zero. This implies annual growth in clean electricity of 165 TWh, compared to annual growth of 17 TWh since 2020.

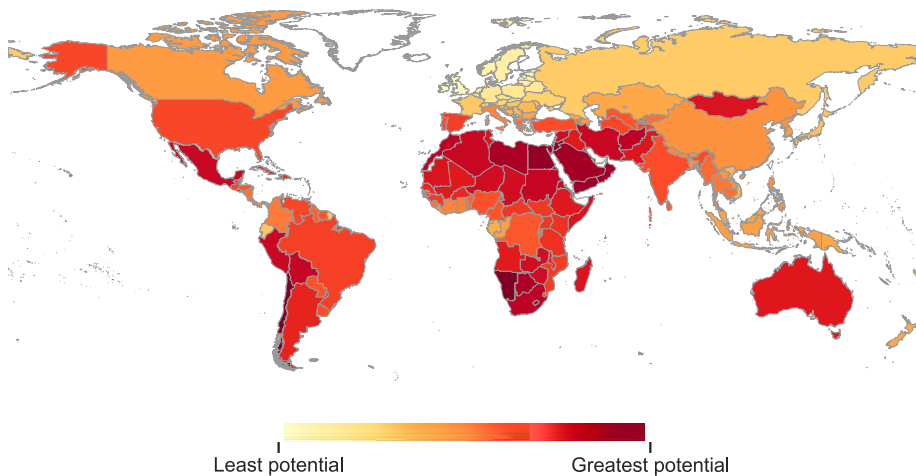
6 Bruegel calculations based on the Ember electricity dashboard (<https://ember-energy.org/data/electricity-data-explorer/>).

Meeting these green energy requirements is challenging because domestic production faces constraints. Land availability for new construction is limited, and voters sometimes push back against construction near to their homes. While 51% of Germany is potentially suitable for wind deployment, just 9% remains after regulatory, environmental, and technical constraints are accounted for (McKinsey, 2022).

The distribution of renewable energy endowments (mountains for hydroelectricity, solar irradiation and high and consistent wind speeds) further limits regional green energy potential. Regions with good renewable energy endowments are often located far from industrial demand centres. The continental electricity system needs major investment and political impetus in order to move green energy around efficiently (Heussaff and Zachmann, 2025).

Europe's solar PV potential is particularly poor – except for the Mediterranean countries. Figure 2 shows 'practical' solar PV potential, a measure that reflects both theoretical solar PV potential (determined by climatic variables such as solar irradiance and air temperature) and land availability, excluding land with physical or technical constraints, such as built-up environment or rugged terrain (ESMAP, 2020).

**FIGURE 2 AVERAGE PRACTICAL SOLAR PV POTENTIAL (KWH/KW)**



Note: We plot the variable average practical potential (PVOUT Level 1) from the dataset.

Source: Bruegel based on ESMAP (2020).

While nuclear energy can play an increasingly important role in supporting electrification in Europe – particularly by providing much-needed low-carbon dispatchable power to complement the variability of renewables – it remains a relatively costly way of compensating for the continent's limited renewable energy endowment. The levelised cost of electricity for new nuclear in advanced economies remains significantly above that of solar and wind. Nuclear projects are capital intensive and subject to long permitting procedures and, very often, significant construction delays. Political and societal

resistance to nuclear energy in several European countries further limits its deployment potential. Advanced nuclear reactors – including small modular reactors – promise to overcome these barriers, but it is unclear whether this promise will be delivered, as development of the technology is still at an early stage.

Attempting to meet all the European Union's clean energy needs domestically would thus result in higher energy costs than in other regions, and is unlikely to be desirable either politically or economically (Neumann et al, 2024). The European Union faces a 'make or buy' decision: how much green energy to produce domestically and how much to import (Scholten et al, 2016). Regional differences in the social acceptance of land use and the possibility for spatial arbitrage imply that some green energy imports are efficient and likely (Schmidt et al, 2019).

## 2.2 IMPORTING ENERGY-INTENSIVE INPUTS IS CHEAPER THAN IMPORTING ENERGY DIRECTLY

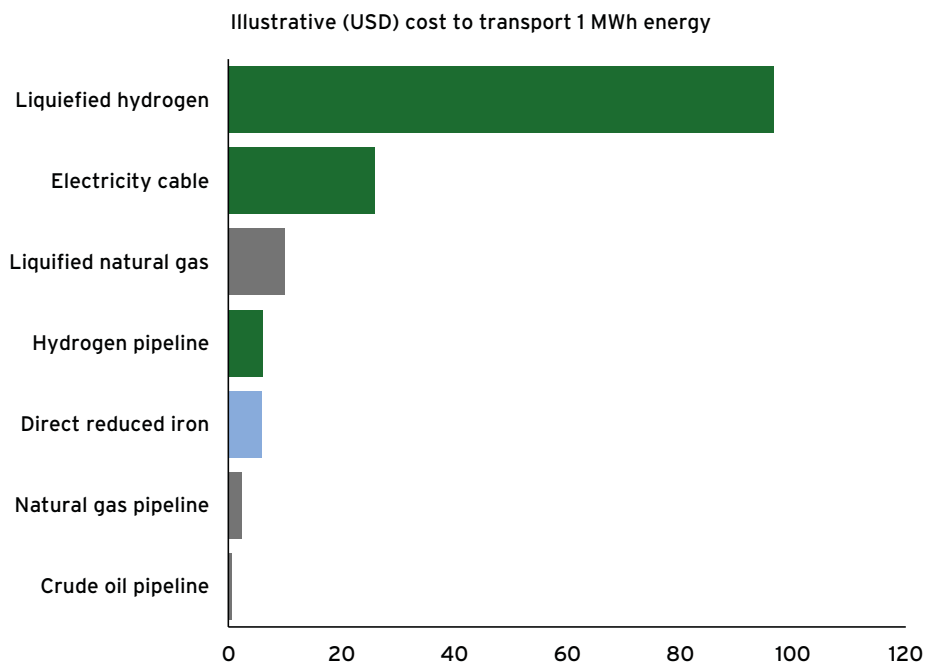
It is substantially more expensive to transport electricity and hydrogen than oil and gas (Saadi et al, 2018; DeSantis et al, 2021). Transportation costs are sufficiently high to make imports of green hydrogen from North Africa or Chile (where production is far cheaper than in Europe) economically unattractive (Galimova et al, 2023; McWilliams and Zachmann, 2021).

Figure 3 shows estimates of the costs of transporting one unit of energy via different clean and fossil-energy carriers. Liquid fuels are more expensive to transport because of fixed liquefaction and regasification costs, which dominate overall costs. We compare these fossil and green-energy costs to the implied costs of transporting green energy contained within reduced iron.<sup>7</sup> The implied cost is higher than for gas and oil via pipeline, but cheaper than green alternatives.

Therefore, the future global green energy system will likely be characterised by far less direct energy trade than currently. The present reality in Europe does little to dispel this notion. Only a small share of electricity is imported, while plans for hydrogen pipelines are long delayed.

7 We assume freight rates are the same as for moving iron ore, as in Bilici (2024). At a freight rate of \$10 per tonne, the implied energy transfer cost per 1 MWh is \$5.90.

FIGURE 3 STYLISED COSTS OF TRANSPORTING ONE UNIT (MWH) OF ENERGY FOR 1,000 KM



Note: amortised costs of transporting one unit of energy (a MWh) in different forms through pipelines (crude oil and natural gas) and electricity through a high voltage direct current line from DeSantis et al (2021), and for hydrogen through a pipeline from Guidehouse (2022). For the transport of liquid fuels, we use a set of assumptions on the costs of liquefaction, freight rates and regasification at destination terminals, based on Al-Breiki and Bicer (2020), Johnston et al (2022), Connelly et al (2019), ACER (2024); Gaffney Cline (2024) and FTI Consulting (2024).

Source: Bruegel.

Meanwhile, the uneven distribution of green energy endowments will create economic pressure for industrial relocation and trade in both final goods and intermediate inputs. This pressure will be particularly strong for commodities or products for which energy costs are a large share of total production costs (Samadi et al., 2023). Examples include ammonia and methanol (inputs into long value chains including fertilisers, synthetic fuels, olefins, resins and other high-value chemicals), and reduced iron, which can be transported by sea, much like iron ore is today, and accounts for approximately 70% to 80% of the energy consumption across the green primary steel value chain (Box 1). At the same time, there is little relocation pressure beyond intermediate products because the energy demand for production of semi-finished products, such as flat steel products or plastic pellets, is low and transport costs are not reduced further compared to transporting intermediate products.

### BOX 1 IMPLICATIONS OF ENERGY COST DIFFERENTIALS FOR TRADE IN INTERMEDIATE INPUTS

Steel offers a clear example of the potential for trade in green intermediate products. Traditional production of primary steel involves burning iron ore using coking coal, both of which are imported by European steelmakers. A potentially economically attractive decarbonisation pathway for the production of green steel is to reduce iron ore using hydrogen instead. Reduced iron can then be transported by sea, much like iron ore today. Producing reduced iron would account for up to 80% of the energy consumption across the green primary steel value chain (Vogl et al, 2018; Alikulov et al, 2024). European steelmakers who want to green their production must thus choose between importing reduced iron or importing iron ore and importing or producing hydrogen.

Taking a global perspective, Bilici et al. (2024) showed that increasing trade in green reduced iron could reduce global production costs for steel by 2.2% to 3.9%. Gielen et al. (2020) found it would be efficient for Australia to shift from exporting iron ore to green reduced iron. This could reduce global emissions while maintaining steel production in countries that currently process iron ore into steel, including Japan, South Korea and China.

For Germany, Egerer et al. (2023a) evaluated the three sectors with the highest projected hydrogen demand: green iron for steelmaking, ammonia production and conversion into urea, and methanol production and processing into ethylene. For each value chain they assessed full domestic production, hydrogen imports to feed domestic value chains, imports of intermediate products for further processing, and imports of final products. They found that energy costs will impact future green value chains, and that relocation of some productive capacity to countries with excellent renewable energy conditions is likely. The effects are most striking for urea and ethylene, for which full German domestic production and hydrogen imports would be uncompetitive internationally - 15% to 25% more expensive than production abroad. Only by importing intermediate products does final urea and ethylene production in Germany become internationally competitive.

Verpoort et al. (2024) performed a similar analysis and arrived at similar conclusions. Importantly, they found that trading intermediate products (reduced iron, ammonia, and methanol) would eliminate “almost all relocation savings” because the energy demand for producing semi-finished products is relatively low.

Green steel value chains are only just emerging and hence empirical evidence on relocations is lacking. However, ArcelorMittal has expressed interest in importing reduced iron to its European plants.<sup>8</sup> A survey of managers at the world’s 50 largest steel and chemical companies found renewable energy potential to be the most important factor influencing locational investment decisions (Eicke and Quitzow, 2025).

8 “Green hydrogen is too expensive to use in our EU steel mills, even though we’ve secured billions in subsidies”, Hydrogen Insight, 21 February 2024 (<https://www.hydrogeninsight.com/industrial/green-hydrogen-is-too-expensive-to-use-in-our-eu-steel-mills-even-though-weve-secured-billions-in-subsidies/2-1-1601199>).

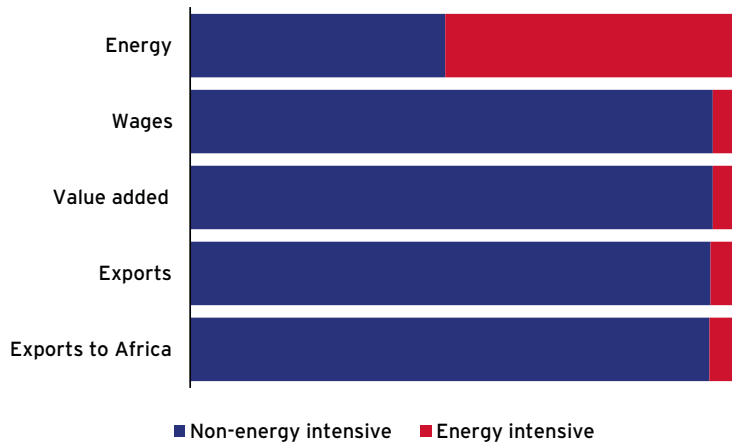
## 2.3 Economic costs for the European Union

Offshoring of the most energy-intensive intermediate inputs could negatively impact industrial activity in the European Union through the loss of some industrial jobs and value added, and via spillover effects that reduce output in the rest of industry. However, these effects are likely small.

### *Direct impact on value added and employment*

The relocation of green energy-intensive manufacturing would not have major direct effects on the European economy. High energy consumption occurs at early stages of value chains, where wages and value added are relatively small. For context, just eight industrial processes account for over half of German industrial energy demand, while providing 5% of wages, 6% of value added, and 7% of exports (Figure 4).

**FIGURE 4 DISTRIBUTION BETWEEN INTENSIVE AND NON-ENERGY-INTENSIVE INDUSTRIAL ACTIVITIES IN GERMANY**



Note: Data are at the granularity of up to four-digit industry (WZ) code. An energy-intensity indicator is calculated using energy consumption and turnover by industry. The eight most energy-intensive industry codes are assigned to the 'energy-intensive' category. These are 2351 (manufacture of cement); 241 (basic iron and steel and ferro-alloys); 2011 (industrial gases); 2015 (fertilisers and nitrogen compounds); 2014 (other organic basic chemicals); 2311 (flat glass); 2352 (lime and paperboard); 2362 (paper and paperboard).

Source: Bruegel based on DeStatis.

### *'Cascading' deindustrialisation?*

'Cascading effects' could spill over onto later value chain stages. This could happen if many industrial processes see the benefits of being located near to intermediate product output, both for supply chain efficiencies and agglomeration benefits. Whether this happens depends on the interplay of unit transport costs and the economic inefficiencies associated with different value chain stages being dispersed. If transport costs for a set of tradeable energy-intensive products are low compared to agglomeration advantages,

factors including skilled labour availability and proximity to demand play more important roles in the locational decisions of any later or associated value chain stages. This is the case for most current industrial processes, which locate largely independently of fossil fuel or mineral reserves.

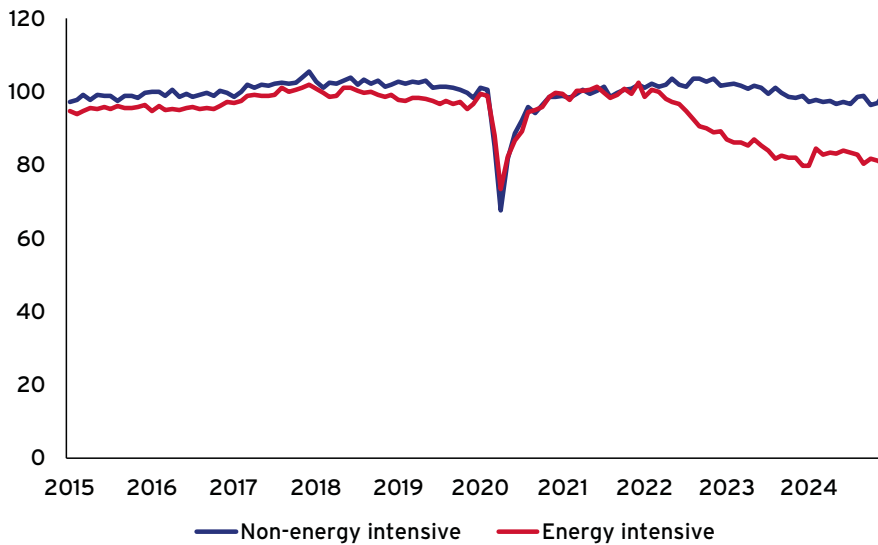
For steel, the costs of transporting direct reduced iron are similar to the costs for transporting iron ore (Bilici et al., 2024), suggesting there will not be major pressure for other iron and steelmaking processes to locate alongside DRI production. Germany's steel industry in the twentieth century grew close to locally sourced coal and iron. As domestic coal production and iron ore extraction were phased out in favour of imports, locations have remained resilient (Egerer et al, 2023a). For the chemical sector, ammonia – produced from natural gas – is already a widely traded intermediate product (Egerer et al, 2023b).

A more explicit evaluation of the output spillovers of reducing or relocating energy-intensive production can be performed by taking the 2022 energy crisis as a natural experiment. Russia's full-scale invasion of Ukraine and the associated gas export cut-off led to soaring prices in the European Union and a reduction in output from energy-intensive industrial processes. The eight most energy-intensive industries saw output drop by one-fifth (Figure 5).

At the onset of the crisis, the aggregate economic impacts on the German economy were the subject of much debate. Estimates for the GDP impact from a full Russian gas cut-off varied wildly from a 2% to 12% loss (Moll, 2024). Larger negative estimates were driven by the assumption that a reduction in output from one area of the economy would have substantial knock-on effects on other processes. Fortunately, this did not happen. While production from energy-intensive industries fell by one-fifth, output from the rest remained broadly flat, despite inflationary pressures, geopolitical tensions, and a large drop in European demand for automobiles (Figure 5).

Part of the reason is that firms shifted into higher value-added products and used fewer intermediate products. This led to a decoupling of industrial output (which fell) and manufacturing value-added in Germany, which remained steady (Fletcher et al., 2024). Firms also increased imports of intermediate products (Fontagné et al., 2023). These imports helped replace outputs from domestic energy-intensive processes, which in turn helped maintain the production of final products (Chiacchio et al., 2023). For fertiliser production in Germany, Stiewe et al. (2022) found that growth in imports replaced domestic production of ammonia, keeping fertiliser production steady.

FIGURE 5 INDEXED EU INDUSTRIAL OUTPUT, ENERGY-INTENSIVE AND NON-ENERGY-INTENSIVE SECTORS



Note: Data from DeStatis are used to assign energy intensity values to industrial processes at the three-digit NACE level by comparing turnover and energy consumption (as in Figure 3). The set of most energy-intensive industrial processes is then mapped to Eurostat industrial output data to define the 'energy-intensive' and 'non-energy-intensive' lines.

Source: Bruegel based on DeStatis and Eurostat.

## 2.4 Economic benefits for the European Union

The economic benefits of increased imports of energy-intensive intermediate goods can also be thought of in terms of direct and spillover effects:

- **Direct benefits to EU downstream industries.** The relocation abroad of early value chain stages can have positive economic effects by lowering input costs for downstream industries in the importing country. This argument applies both to the downstream stages of energy-intensive production and to associated services. For example, the international division of solar PV value chains has facilitated a boom in solar service jobs in Europe and the United States.<sup>9</sup>
- **Spillover benefits for other industrial sectors and consumers.** Bas and Strauss-Kahn (2014) investigated firm-level imports into France from 1996 to 2005, finding that imported inputs raised productivity and exports. New imported inputs have been shown to facilitate the introduction of new products in the European Union (Colantone and Crinò, 2011). In relation to imported energy-intensive products, the likely channel for beneficial spillovers will be electricity price cuts for other industrial consumers and for households, boosting competitiveness and making energy more affordable.

9 See the Bruegel European Clean Tech Tracker (<https://www.bruegel.org/dataset/european-clean-tech-tracker>).

The magnitude of both effects will depend on the volume of energy embodied in imported intermediate inputs and its effect on prices. A rough estimate (see the Appendix) suggests that imports of direct reduced iron, ammonia, and methanol could reduce EU electricity demand by more than 500 TWh. This is more than one-quarter of today's green electricity production in the European Union, and around one-tenth of 2050 projected demand. Trade in other products that undergo energy-intensive processes, such as polysilicon, refined minerals, and aluminium, would increase the savings. It is also conceivable that air and sea transportation will be decarbonised by the use of synthetic hydrocarbons – chemical fuels that replicate mineral fuels such as kerosene but are produced using electricity to combine hydrogen with captured carbon dioxide. Synthetic hydrocarbons might be considered a form of intermediate product, potentially adding another large chunk of tradeable embedded energy.

EU imports of green energy embedded in basic intermediate products could thus potentially reduce future green-energy demand by substantially more than 10%. The extent to which prices would be impacted would depend on price elasticities of supply and demand. For context, the European energy crisis of 2022 saw the loss of about 20% of natural gas supply, though impacts were dramatically exaggerated by the immediate and unexpected nature of the shock, which would not be the case for a longer-term structural reduction.

Importantly, maintaining some energy-intensive green-energy demand in the European Union can have a positive system effect to the extent that it is flexible and can load-shift to follow swings in supply. Large point sources of electricity demand, which can quickly ramp their consumption up and down, can act almost as batteries – consuming when there is too much green energy in the grid and turning off when it is scarce. Therefore, maintaining some production of energy-intensive goods in Europe likely to be efficient (Neumann et al., 2024).

## 2.5 Economic security

De-risking the European economy is a priority concern for policymakers, reinforced by ongoing impacts from the Russian gas cut-off. Sustainable green industrialisation requires de-risking of external economic relationships while maintaining most benefits of trade.

Developing new import relationships will expose European countries and companies to international supply-side risks. Natural disasters or political changes could disrupt trade routes and harm production. There is thus a partial trade-off between minimising economic security risks and achieving least-cost decarbonisation.

However, importing more green intermediate products would be less risky than Europe's current dependence on fossil fuels. To the extent that they help reduce fossil fuel imports, imports of green intermediate products can even be security enhancing. Dependence on an imported industrial product is not comparable to dependence on an energy source. A disruption to trade in green intermediate products would affect industrial output, but not household heating or motorists.

Green intermediate products could be sourced from a wide pool of suppliers. The constraints to becoming a supplier are much less restrictive than for the export of fossil fuels, as abundant renewable energy sources (and mineral deposits) are present in many countries (Figure 2). Stockpiling could mitigate risks further. Therefore, while there is a trade-off, it can be offset by best practices that exploit the economic efficiencies of trade while minimising risks (Section 4).

### **3 THE VIEW FROM OUTSIDE: CONSISTENCY WITH THE INDUSTRIALISATION OF THE GLOBAL SOUTH**

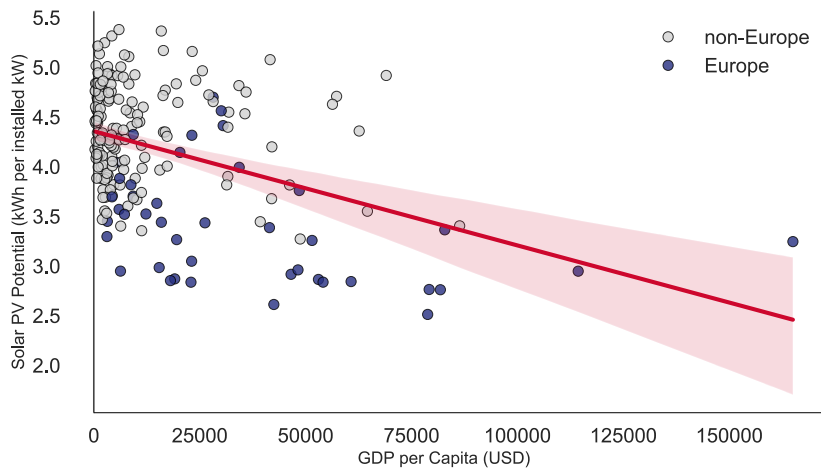
#### **3.1 Economic benefits for the Global South**

European firms currently import fossil fuels and raw minerals from the Global South, with few imports of intermediate products. This does not create significant value added in exporting countries. With weak institutions in exporting countries, it can also lead to the 'resource curse' of policymakers seeking to maximise their shares of rents associated with resource exports, rather than creating good business environments.

An EU shift to more imports of energy-intensive inputs would be much more attractive economically for the Global South. It would see fresh economic activity move to the Global South and diversification away from raw mineral and energy exports toward intermediate products – as happened in South Korea in the 1970s, for example. Many Global South countries have good renewable energy and critical mineral endowments (Figure 6).

Exports of intermediate products will create jobs and value added. For instance, exporting green reduced iron can raise local employment by 16% per tonne of DRI produced in Global South countries compared to exporting the equivalent volumes of green hydrogen and iron ore separately (Agora Industry, 2024). Meanwhile, countries in the Global North would retain more than 90% of existing jobs in the steel value chain, and the final production cost of steel would be reduced by 16%. Caiafa et al. (2025) investigated the Brazilian state of Ceará, from where liquid hydrogen or green steel might be exported to the Netherlands. Performing the additional step of green steel production in Ceará could increase local value added (by 3%), incomes (by up to 23%) and employment (by up to 35%) (Caiafa et al., 2025).

FIGURE 6 PRACTICAL SOLAR PV POTENTIAL VS GDP PER CAPITA



Note: See Figure 2 for solar PV potential (average practical potential, PVOUT Level 1).

Source: Bruegel based on ESMAP (2020).

The desire to onshore additional value chain steps is a clearly stated policy goal for countries of the Global South. Chile is generally considered to have avoided the natural resource curse and been able to translate large resources of copper and lithium into economic growth through industrialisation strategies (Gutierrez et al., 2022). The Indonesian government plans an integrated battery value chain in order to leverage upstream domestic nickel resources that were previously exported (Huber, 2022). Meanwhile, the Democratic Republic of Congo has reviewed agreements with Chinese mining firms that were deemed exploitive and now seeks partnerships with other investors.<sup>10</sup>

Closer to Europe, plans for green-iron production are materialising in North Africa – in Mauritania, for example, where green iron will be produced alongside green hydrogen (Karkare and Medinilla, 2024). ArcelorMittal is exploring green hydrogen, iron, and steel production in Mauritania.<sup>11</sup> In Egypt, Italian group Danieli has submitted a proposal to the government to build a green-steel plant to exports to the European Union,<sup>12</sup> while the German SMS group plans a 2.5 million tonne green iron facility in the Suez Canal Economic Zone, investing \$1.06 billion (Karkare and Medinilla, 2024).

10 “Congo courts Saudi mining investors to help curb China dominance”, Reuters, 14 January 2025 (<https://www.reuters.com/world/africa/congo-courts-saudi-mining-investors-help-curb-china-dominance-2025-01-14/>).

11 See “ArcelorMittal signs MoU with SNIM to evaluate the opportunity to jointly develop a pelletisation plant and DRI production plant in Mauritania”, press release, 25 May 2022 (<https://corporate.arcelormittal.com/media/news-articles/arcelormittal-signs-mou-with-snim-to-evaluate-the-opportunity-to-jointly-develop-a-pelletisation-plant-and-dri-production-plant-in-mauritania>).

12 “Egyptian govt weighs Danieli Group’s plan for green steel complex”, *Renewables Now*, 29 February 2024 (<https://renewablesnow.com/news/egyptian-govt-weighs-danieli-groups-plan-for-green-steel-complex-850074/>).

### 3.2 Global climate benefits

An EU green industrialisation strategy that only stimulates the production of enough green energy for domestic consumption is neither sufficient nor desirable. Establishing early value chains abroad is important for global green industrialisation. Large emission reductions can be driven by countries that specialise in line with their environmental comparative advantages. Modelling the impacts of a carbon tax, Le Moigne et al. (2024) found that just over one-third of global emissions reductions could come from trade-enabled reallocation.

The creation of early green industrial value chains abroad can develop green knowhow and reduce the costs of developing full green value chains abroad. For example, the availability of cheap green iron is the crucial determinant of cost-effective green steel production, and the construction of a first green iron plant (perhaps for export) can reduce the costs of constructing a second (perhaps for domestic consumption).

Green industrial transformation in Europe and green industrialisation in the developing countries can reinforce each other. Huge growth in green industrial product manufacturing is needed and is critical for meeting global climate targets. The European Union accounts for less than 10% of global industrial emissions and much future industrialisation will occur in the Global South.<sup>13</sup> In particular, developing countries lack scrap steel and are forecast to become increasingly dependent on the production of crude steel (Watari et al., 2023), which will be emissions-intensive unless the greening of this production takes place, supported by integration in global value chains. While controversial from an economic security standpoint, the global climate benefits of China leading in the energy-intensive production of solar panels and batteries from the early 2000s have been enormous.

13 The industry sector in 2022 globally was responsible for 9.0 Gt CO<sub>2</sub> emissions (<https://www.iea.org/energy-system/industry>); total emissions from manufacturing in the European Union were 0.7 Gt in 2023 (Eurostat).

## 4 IMPLICATIONS FOR EU ECONOMIC POLICY

To reconcile its clean industrialisation objectives with those of the Global South in a cost efficient and politically viable manner, the European Union needs to adapt its domestic and foreign economic policies.

### 4.1 Domestic economic policy: Smarter industrial policy for energy-intensive sectors

One of the toughest industrial policy questions facing Europe is how to handle energy-intensive industries (EIIs). Should Europe do whatever it takes to retain them all – for reasons spanning from jobs to economic security? Should they be retained on condition that they decarbonise in line with European Green Deal targets? Or should a more selective approach be taken that offers public support only to those EIIs and/or energy-intensive production stages that both embark on a green transformation and are likely to remain competitive, even if energy prices remain higher in Europe than elsewhere?

European governments, with the tolerance of EU state aid rules, have so far largely opted for the first option: subsidising EIIs unconditionally. Energy subsidies are the clearest illustration. On average across Europe, EIIs pay 50% less per unit of electricity consumed than households, and in many countries the gap is even larger (Heussaff et al., 2025). Such differences arise because EIIs can sometimes access better rates from suppliers because of their scale, but also because they often pay lower network costs than households and frequently don't pay certain cost components, such as the costs of public support for new renewable projects.

The second option – maximum effort to retain EIIs provided they decarbonise – was advocated by Draghi (2024), who called for EIIs to be given preferential access to special low-cost electricity generation portfolios, publicly procured liquified natural gas, and further electricity network tariff rebates. To prevent single market fragmentation triggered by national subsidies, and to ensure efficient distribution of activities across the European Union in line with comparative advantage, Draghi (2024) also called for a prominent EU-level component in decarbonisation funding for EIIs, similar to the EU Innovation Fund's 'Hydrogen Bank', and including reformed and expanded Important Projects of Common European Interest (IPCEIs).<sup>14</sup>

The EU Clean Industrial Deal plan (European Commission, 2025a) adopted a version of Draghi's recommendations. It proposes substantial EU-level instruments to fund EII decarbonisation, starting with a €100 billion EU Industrial Decarbonisation Bank to be created alongside the Innovation Fund. But it also proposes a friendlier approach

14 The Hydrogen Bank is a European financing initiative that supports clean hydrogen projects selected through competitive auctions. Consortia of hydrogen suppliers and off-takers bid for a subsidy necessary for their project to be realised. IPCEIs are cross-border projects through which European governments provide financial support to consortia in research, development and infrastructure for critical technologies such as microelectronics, batteries and hydrogen.

to national state aid than Draghi (2024), calling for a new Clean Industrial State Aid Framework that would facilitate national support for EIIs and clean-tech manufacturing, replacing the Temporary Crisis and Transition Framework – Commission criteria for approving state aid “to foster support measures in sectors which are key for the transition to a net-zero”, adopted in March 2023 in response to clean-tech subsidies in the United States.<sup>15</sup>

The second option would be far better than the first. Unlike the first option, it is consistent with Europe’s net zero goals. But it remains problematic from the point of view of European competitiveness and from a global perspective.

From a European perspective, the approaches of Draghi (2024) and the Clean Industrial Deal create a distributional problem that could reduce growth and competitiveness. Subsidising electricity consumed by EIIs implies higher costs for other electricity consumers and possibly taxpayers. For example, reducing electricity prices for EIIs to 2019 levels by shifting system costs among consumers would increase household electricity prices by about 15% (Heussaff et al., 2025). Likewise, removing value-added tax from electricity consumed by EIIs would create significant shortfall in national budgets, as tax revenues from VAT on electricity amount to tens of billions of euros each year in the European Union. Preferential treatment of one category of energy consumer thus inevitably raises issues of fairness and efficiency. It makes no sense for Europe to provide scarce energy at a discount to sectors that provide less value added per unit of energy, rather than allowing less energy-intensive sectors with higher growth potential to flourish.

From a global perspective, the approach is problematic because it ignores the potential for greater gains from global trade and comparative advantage in a decarbonised global economy. Subsidising European EIIs encourages the continuation of high-cost production in Europe, instead of allowing market forces to direct energy-intensive manufacturing to those regions that, thanks to their renewable energy endowments, are best suited for such production. This raises the global cost of decarbonisation. It may also undermine international climate cooperation if developing countries with ample renewable energy endowments become frustrated with the unwillingness of advanced countries to integrate them into green supply chains.

Europe should be more selective when supporting EIIs. Industrial subsidies should depend on two main criteria: the greening of EIIs – an essential step to ensure their long-term international competitiveness in a decarbonising global economy – and the efficiency of production in Europe post-abatement, conditional on realistic assumptions about European energy costs. The latter hinges on two sub-criteria: (i) energy intensity

15 See “Temporary Crisis and Transition Framework”, European Commission ([https://competition-policy.ec.europa.eu/state-aid/temporary-crisis-and-transition-framework\\_en](https://competition-policy.ec.europa.eu/state-aid/temporary-crisis-and-transition-framework_en)).

(how much energy the decarbonised process still requires, and whether this aligns with Europe's future green energy availability and cost); and (ii) cost-effectiveness in a global context (whether similar emissions reductions could be achieved more efficiently by supporting abatement in the Global South, where decarbonisation costs may be lower).

To apply this approach, two main channels through which EIIs are currently subsidised should be distinguished:

- **Allocation of free allowances under the EU Emissions Trading System (EU ETS).** From 2026 to 2034, approximately 2.8 billion EU ETS allowances will be allocated for free – a financial envelope of some €200 billion at current prices. As the point of free allowances is to prevent carbon leakage (i.e., relocation of carbon-intensive industry beyond the reaches of the EU ETS) before the EU Carbon Border Adjustment Mechanism (CBAM) enters fully into force, it is fine to allocate them only based on emissions reductions, ignoring the energy intensity of production.
- **Direct subsidisation of capital expenditure or production, including energy subsidies.** In these cases, it is not acceptable to make subsidies conditional only on abatement. In addition, no subsidies should be provided to highly energy-intensive stages that it would be more efficient to offshore (with the exception of a minimum capacity that might be justified on security grounds).

This approach would allow Europe to maximise the impact of public funds, support industries for which competitive green production is viable, and contribute cost-effectively to global decarbonisation.

#### **4.2 Foreign economic policy: Supporting green industrialisation in the Global South**

To support both global decarbonisation and the competitiveness of European production, selective domestic subsidies need to be complemented by a strong foreign economic policy that supports the development of manufacturing capabilities for energy-intensive intermediate products in Global South countries that are rich in both raw materials and renewable energy endowments, and integrates these products into Europe's green supply chains.

The European Commission has proposed Clean Trade and Investment Partnerships (CTIPs; European Commission 2025a, Section 6.1). While detail and a framework are lacking at the time of writing (some detail has been offered on the first CTIP being prepared with South Africa), this initiative is potentially important. Through CTIPs, the European Union could engage with third countries more coherently than currently. The European Union already runs several initiatives in parallel – including Energy

Partnerships, Green Partnerships, Critical Raw Materials Strategic Partnerships, and the Global Gateway – but these are often in silos. This prevents an integrated approach covering the whole green product supply chain, and makes EU climate and industrial diplomacy less efficient.

To be credible, CTIPs should be structured not only as trade diplomacy platforms, but as practical toolkits including both supply- and demand-side instruments to mobilise private sector investment in green value chains.

On the supply side, blended finance instruments should be deployed, including those already available through the Global Gateway, new resources under the next EU budget (2028-2034), and from the European Investment Bank. This will reduce investment risk and crowd-in private capital. Technical cooperation on setting and harmonising green standards is also required, particularly for emerging sectors such as green steel, green cement and green chemicals, for which early alignment can shape global norms. Support for local green industrial ecosystems is essential. This could take the form of joint industrial clusters, similar to efforts in Namibia, where European and local firms collaborate to build integrated, low-carbon value chains.<sup>16</sup> Replicating and scaling up such initiatives elsewhere – especially in countries rich in renewable energy and critical raw materials – would help embed industrial value creation locally, promote technology transfer, and ensure that green value chains deliver inclusive growth and environmental benefits.

On the demand side, the credibility and success of CTIPs will depend on Europe's ability to offer stable and attractive long-term market signals. Guaranteed offtake agreements for the intermediate green products produced in the Global South under CTIPs should be supported, for instance by allowing them to qualify under sustainability and resilience criteria<sup>17</sup> in the EU Net-Zero Industry Act (Regulation (EU) 2024/1735). Expanding the geographical scope of such criteria to include CTIP partner countries could greatly enhance the cost-efficiency and the effectiveness of the measure.

The European Union could also promote joint offtake pools or demand-aggregation platforms, similar to H<sub>2</sub>Global, a German scheme to support investment in renewable hydrogen production in non-EU countries, which will be then imported and sold in the European Union. The H<sub>2</sub>Global scheme works as a double auction model, with the German government providing a subsidy to the most competitive bids for exporting green hydrogen (or derivatives such as ammonia) into Germany.

16 In November 2022, Namibia and the European Union signed a memorandum of understanding for a strategic partnership in sustainable raw materials value chains and renewable hydrogen, with the goal of mobilising €1 billion in investment from the European Union, EU countries, and European financial institutions. See "Global Gateway: EU and Namibia agree on next steps of strategic partnership on sustainable raw materials and green hydrogen", European Commission press release, 24 October 2023 ([https://ec.europa.eu/commission/presscorner/detail/en/ip\\_23\\_5263](https://ec.europa.eu/commission/presscorner/detail/en/ip_23_5263)).

17 These require public authorities to take into account non-price criteria for certain net-zero technologies in procurement processes and in auctions for the deployment of renewable energy.

A broader range of green projects in third countries could also be fostered under the EU Innovation Fund – as is being done for hydrogen. By supporting green intermediate products outside the European Union and linking them to guaranteed demand in Europe, such mechanisms would help anchor investment decisions in partner countries and deepen industrial cooperation along clean value chains. By integrating these demand-side tools, CTIPs can help bridge the commercialisation gap, making green industrialisation projects in partner countries bankable and scalable, while reinforcing the European Union’s own industrial resilience and climate leadership.

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## **APPENDIX: A ROUGH ESTIMATE OF EUROPEAN INTERMEDIATE PRODUCT GREEN ENERGY DEMAND**

We estimate the green energy demand required to produce three intermediate products in Europe: direct reduced iron as an input to the steel value chain, and ammonia and methanol as intermediate products for chemicals value chains (e.g., Egerer et al., 2023a).

We start with current demand for each product in the European Union and estimate the volume of green energy that would be required to produce a similar volume of green products. For steel and ammonia, we assume constant demand; for methanol, we assume an increase in demand because there is significant potential for methanol to replace some current hydrocarbon uses.

In 2023, the European Union produced 126 million tonnes of crude steel (Eurofer, 2024), via two production routes: blast oxygen furnaces and electric arc furnaces. An electric arc furnace consumes electricity, and overall emissions can largely be removed through the use of green electricity. Therefore, steel decarbonisation through hydrogen aims to replace supply from blast oxygen furnaces.

We calculate the hydrogen required to provide enough direct reduced iron to replace current EU blast oxygen furnace production of 70 million tonnes of steel annually (Eurofer, 2024). Producing one tonne of direct reduced iron requires 60 kilogrammes of hydrogen (Egerer et al., 2023a). One kilo of hydrogen is equivalent to 33 kWh energy. Therefore, the required hydrogen energy demand to produce 70 million tonnes of direct reduced iron is 140 TWh.

For ammonia, EU demand is 19 million tonnes, with 17 million tonnes produced domestically and net imports of 2 million tonnes (Kneebone and Piebalgs, 2023). We calculate the hydrogen required to replace all this demand domestically. The requirement to produce one tonne of ammonia is estimated at 197 kilos of hydrogen, or approximately 6,500 kWh of hydrogen energy. Total demand is therefore estimated at 125 TWh.

Current EU demand for methanol is a little under 10 million tonnes. Renewable methanol demand could replace conventional fossil methanol demand, but potentially also certain hydrocarbon uses – synthetic hydrocarbons can be produced using methanol as a base. Methanol demand in the European Union might therefore grow to 18 million tonnes by 2030 (Kneebone and Piebalgs, 2023). Producing one tonne of methanol requires 210 kilos of hydrogen (Egerer et al., 2023a), equivalent to 7,000 kWh hydrogen energy. This implies total demand of 125 TWh of hydrogen.

For the European Union to produce sufficient quantities of the three intermediate products, 390 TWh of hydrogen may therefore be required in total. There is considerable uncertainty about future demand and technologies and so this number is only illustrative of the potential. Producing this hydrogen domestically would require a little over 550 TWh of green electricity production, assuming an electrolyser operating at 70% efficiency.



# Planetary waste management - a game changer for climate policy?<sup>1</sup>

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## 1 THE STATUS QUO OF CLIMATE POLICY

With the European Climate Law, the European Union has committed to net-zero emissions by 2050. Germany wants to achieve climate neutrality by 2045. Many cities and multinational corporations are also pursuing this goal, which is politically sensible and scientifically sound. In the Paris Agreement, the international community agreed to limit the rise in global mean temperature to below 2°C, or even 1.5°C if possible. This sets the cumulative amount of greenhouse gases that can still be deposited in the atmosphere. Net-zero emissions are also to be achieved globally by the middle of the century (UNFCCC, 2023). Nevertheless, global emissions are rising. The energy policies of many countries do not indicate a clear commitment to phasing out fossil fuels (UNEP, 2023a). International climate policy is in danger of failing to meet its targets. In view of the increasing climate damages, scientists and politicians are discussing the possibility of directly controlling the radiation balance by injecting aerosols into the atmosphere. The international community is divided on this issue (Biermann and Gupta, 2024). This is because it is a dangerous undertaking to try to directly control the Earth's radiation balance. Precipitation patterns in many regions of the world could change, the geopolitical risks of aerosol injection are poorly understood, and there is no international agreement in sight on the use of these technologies (UNEP, 2023b).

Our core thesis is therefore that the two traditional pillars of climate policy – reducing emissions and adapting to climate change – are indispensable, but not sufficient. Climate policy needs a third pillar – that of technologies for removing emissions from the atmosphere. Here, conventional processes, such as afforestation and reforestation, or novel technical processes, such as air filters and subsequent geological storage, should

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remove enough carbon dioxide (CO<sub>2</sub>) from the atmosphere and store it in carbon sinks to overcompensate for emissions from the combustion of fossil fuels and land use. This would result in net-negative emissions in the second half of the 21st century, which would overcompensate for temperature overshoot in the first half (Smith et al., 2024).

In fact, scenarios that limit global warming to below 2°C or even 1.5°C often require a large-scale deployment of carbon dioxide removal (CDR). Some models project gross CDR volumes of 10–20 GtCO<sub>2</sub> per year by the second half of the 21st century – equivalent to one-quarter to one-half of current emissions (IPCC, 2018). Beyond offsetting residual, hard-to-abate emissions, net CO<sub>2</sub> removal could even exceed emissions, leading to net-negative emissions. In particular, if mitigation efforts are insufficiently ambitious, net-negative emissions may be required to return to a temperature target after an overshoot. Moreover, if the social cost of carbon (SCC) is sufficiently high, the current atmospheric CO<sub>2</sub> concentration may already exceed the cost-optimal level. Finally, net-negative emissions could serve as a means of addressing historical responsibility for climate change. Countries that have emitted disproportionately due to early industrialisation could use CDR to partially compensate for their past emissions.

In this chapter, we will show how the optimal division of labour between emissions abatement, adaptation, and carbon removal from the atmosphere should be determined in a welfare economic perspective. We will explain why CDR can be seen as a game changer in climate policy: the more the damage of climate change increases – and thus the SCC – and the higher the expected cost reduction potential of the removal options, the earlier the net-negative phase of climate policy will be ushered in. Although there is still considerable uncertainty about the expected cost reduction potential (Smith et al., 2024), there is enough clarity about the SCC. Recent research suggests it will rise sharply. Kotz et al. (2024) use data at the subnational level to show that not only the rise in temperature, but also extreme weather events, climate variability, and precipitation patterns significantly increase global climate damage. Bilal and Känzig (2024) distinguish between damage caused by local and global temperature changes. They give a range for the social cost of carbon of between \$700 and \$1,800 dollars per ton of CO<sub>2</sub>. Both studies suggest that the damage estimates could be significantly revised upwards compared to those of the US Environmental Protection Agency (EPA, 2023).

We embed new CDR options in the industrial management of the global carbon cycle and also answer the question of how carbon sinks that do not offer permanent storage should be valued economically. German and European climate policy is accused of notoriously neglecting international cooperation – and not entirely without justification. We therefore assess to what extent carbon removals are capable of improving international cooperation. The provision of carbon sinks requires permanent funding, and it is unlikely that the European finance ministers will provide the necessary funds. The development of a CDR sector in Europe (but also beyond the continent) therefore only has a chance if European emissions trading is able to finance negative emissions. We show that this is possible through the introduction of so-called clean-up certificates. The

necessary management of carbon markets could overburden the European Commission. We therefore advocate the establishment of a European Carbon Central Bank (ECCB). The timing for this discussion is favourable: the Commission is currently exploring how to address residual industrial emissions – such as those from the cement sector – that are difficult to eliminate. The aim is to offset these emissions through carbon removals, thereby preventing a sharp increase in prices within the emissions trading system (European Scientific Advisory Board on Climate Change, 2025).

The remainder of this chapter is organised as follows. We summarise the status quo of CDR research, development, and deployment in Section 2. In Section 3, a welfare-theoretic framework is introduced to integrate CDR into the three pillars of climate policy – mitigation, adaptation, and removal. Section 4 develops the concept of the ‘green zero’, emphasising the need for hard intertemporal carbon budget constraints in the face of increasing climate damages and uncertain technological progress. In Section 5, we explore the interaction between CDR technologies and the global carbon cycle, highlighting the challenges and opportunities of different removal approaches. Section 6 then turns to the role of international cooperation in scaling CDR, followed by Section 7, which examines how the EU Emissions Trading System aligns with the green zero. Finally, concluding remarks are offered in Section 8.

## **2 THE STATUS QUO OF CDR TECHNOLOGIES, RESEARCH, DEVELOPMENT, AND DEPLOYMENT**

There are different ways of classifying CDR technologies. Smith et al. (2024) distinguish between conventional and novel methods. Conventional methods include, for example, afforestation and reforestation, agroforestry, soil carbon sequestration, as well as peatland and coastal wetland restoration. These are used at scale already and are well established. Novel methods, by this classification, therefore include all other technologies. They are characterised by their considerably smaller scale of, and readiness for, deployment. Storage takes place in geological formations, the oceans, or products. Examples include bioenergy with carbon capture and storage (BECCS), direct air carbon capture and storage (DACCS), enhanced rock weathering, biochar, and ocean alkalinity enhancement. In Table 1, we summarise some key aspects of different CDR technologies. Taylor et al. (2025) distinguish the latter set into cyclic and once-through technologies. Cyclic CDR systems, such as chemical direct air capture, repeatedly use the same materials to extract carbon from the atmosphere. While inherently energy-intensive, these systems offer the advantage of more easily verifiable carbon sequestration with potentially lower environmental impacts compared to other CDR approaches. Once-through CDR systems, such as enhanced rock weathering (ERW) and ocean alkalinity enhancement (OAE), rely on a single-use resource, often involving minerals extracted from the Earth, to capture CO<sub>2</sub> directly or indirectly. While these approaches tend to be less energy-intensive, they typically require large-scale resource extraction, which can lead to significant environmental impacts. Additionally, measuring and verifying their effectiveness remains a challenge.

**TABLE 1 CDR METHODS: POTENTIALS, COSTS, AND TECHNOLOGY READINESS RANGING FROM 1 (BASIC PRINCIPLES DEFINED) TO 9 (PROVEN IN OPERATIONAL ENVIRONMENT)**

CDR technology	Potential (GtCO <sub>2</sub> /yr)	Cost (USD/tCO <sub>2</sub> )	TRL
Afforestation/Reforestation	0.5-10	0-240	8-9
Soil Carbon Sequestration	0.6-9.3	-45-100	8-9
Biochar	0.3-6.6	10-345	6-7
BECCS	0.5-11	15-400	5-6
DACCS	5-40	100-300	6
Enhanced Weathering	2-4	50-200	3-4
Ocean Alkalinity Enhancement	1-100	40-260	1-2
Ocean Fertilisation	1-3	50-500	1-2

Note: Cost and global mitigation potential are estimated for 2050.

Source: Based on IPCC (2022).

According to Smith et al. (2024), investments in CDR research and development (R&D) have grown steadily, with third party-funded research grants increasing from fewer than 50 in 2000 to over 1,160 in 2022, amounting to an estimated \$2.6 billion in total funding. While conventional methods like biochar, soil carbon sequestration, and afforestation dominate research, newer approaches such as DACCS and BECCS receive significant funding due to larger project sizes. Most grants are concentrated in Canada, the United States, and non-EU European countries like Norway, Switzerland, and the United Kingdom, with comparatively lower activity in the EU27. Scientific publications on CDR have surged, particularly in emerging areas like DACCS, coastal wetland restoration, and enhanced rock weathering. However, inventive activity, measured by international patent families, has declined since 2011, largely due to slower patent growth in BECCS, though biochar patents are rising. Despite overall growth and some diversification, ocean-based CDR and research in sub-Saharan Africa, Latin America, and the Middle East remain limited.

Demonstration projects, investments in new firms, and expectations of growth are crucial for scaling up CDR. Smith et al. (2024) report that there is increasing activity in all three areas, though sustaining this growth presents challenges. The number and capacity of demonstration plants have expanded rapidly, with the United States leading efforts through a well-funded programme supporting a 1 million ton per year direct air capture (DAC) plant and another in negotiation. The US DAC hubs represent the most substantial public demonstration initiative, while the Mission Innovation CDR Launchpad, though smaller in funding, fosters future investment and knowledge-sharing. Investment in CDR startups grew significantly over the past decade but declined in 2023, reflecting broader

market volatility. Growth in novel CDR startups outpaces that of conventional ones, yet companies face scaling challenges. Industry and CDR firms have set ambitious capacity targets for mid-century, but comprehensive funding data remain sparse. Improved data collection is essential for tracking and managing the evolving CDR landscape.

Currently, according to Smith et al. (2024), a total of 2 GtCO<sub>2</sub> per year are removed with CDR technologies, most of which is via afforestation. Most CDR is deployed in China, the United States, Brazil, and the Russian Federation. The largest current contributions from novel CDR methods result from biochar (with an estimated 0.79 MtCO<sub>2</sub> per year), bioenergy with carbon capture and storage (0.51 MtCO<sub>2</sub> per year), and enhanced rock weathering (0.03 MtCO<sub>2</sub> per year).

### 3 THE THREE PILLARS OF CLIMATE POLICY: AN INTEGRATED WELFARE THEORETIC PERSPECTIVE

The welfare-optimal division of labour between emissions abatement, adaptation, and carbon removal can be determined by a simple static optimisation problem. The goal of the social planner is to minimise the sum of the damage caused by climate change  $D$  and the costs due to adaptation  $A$ , abatement  $M$ , and removal  $R$ . Net emissions  $E^n$  increase climate damage, while adaptation reduces it. The net emissions are determined by the difference between the emissions in the business-as-usual pathway  $E^{BAU}$  and the emissions reduced by abatement and removal. The net emissions can be positive or negative. Equations (1) and (2) describe the necessary conditions that also determine the optimal division of labour between the three sectors:

$$\min_{A,R,M} SWF = D(E^n, A) + C^M(M) + C^R(R) + C^A(A)$$

$$s.t. E^n = E^{BAU} - M - R$$

$$SCC = \frac{\partial D}{\partial E^n} = C_M^M = C_R^R \quad (1)$$

$$-\frac{\partial D}{\partial E^n} = C_A^A \quad (2)$$

In this case, partial derivatives are shown subscripted by a variable, that is,

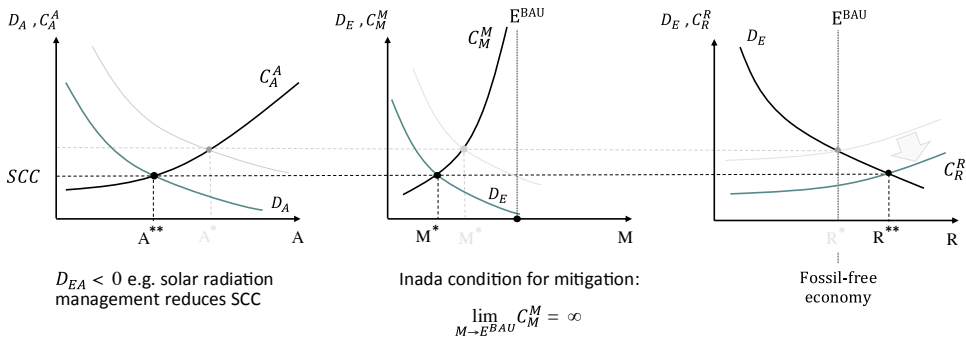
$$C_M^M = \frac{\partial C^M(M)}{\partial M}, \quad C_{MM}^M = \frac{\partial^2 C^M(M)}{\partial M^2},$$

According to equation (1), the social cost of carbon – that is, the marginal damage caused by climate change – must correspond to the marginal costs of the abatement and removal sectors.

Equation (1) shows two further fundamental principles. In a first-best welfare optimum, emissions must be priced at the resulting climate damage (the SCC). This can be done using either the polluter-pays principle or the compensating-the-polluter principle. The provision of carbon sinks must also be compensated to the same extent, as they relieve the burden on the atmosphere as disposal space. ‘Cleaning up the mess’ is another fundamental ethical principle here, in addition to the polluter-pays principle, which must be taken into account in a reorganisation of international climate policy. As we are assuming that the second law of welfare theory applies here, distributional issues can be discussed independently of efficiency. For example, it is an open question to what extent those who have made particularly intensive use of the atmospheric disposal space in the past should be involved in financing carbon sinks.

In order to assess the significance of CO<sub>2</sub> removal for climate policy, an Inada condition must be taken into account, which distinguishes the abatement sector from the removal sector: the marginal cost of abatement converges towards infinity if almost all emissions of the business-as-usual (BAU) scenario are to be avoided. The Inada condition does not apply to the removal sector, which can generate large quantities of negative emissions at finite marginal costs. If the sum of abatement and removal exceeds the emissions of the BAU scenario, net-negative emissions are generated. If the marginal costs of removal fall, the SCC falls because the climate damage is reduced by the additional carbon removed. This also eases the burden on adaptation and abatement within climate policy (see the middle and right panels in Figure 1).

FIGURE 1 OPTIMAL DIVISION OF LABOUR BETWEEN THE THREE PILLARS OF CLIMATE POLICY



We are interested in the question of what role carbon removal should play in future climate policy. Therefore, a comparison between removal and solar radiation management (SRM) as a particular form of adaptation will be made. We assume that the latter reduces the temperature by directly changing the Earth’s radiation balance through the introduction of aerosols into the stratosphere or by setting up solar sails in space. SRM is a highly controversial technology (Oomen and Niesen, 2024) and the uncertainties surrounding its negative effects may appear larger than those of CDR. However, to date, there has been no systematic comparison of the risks associated with SRM and the costs

associated with CDR (Rabitz, 2024). Nevertheless, we can still compare SRM and CDR based on their fundamental properties. If there were only temperature-related damage, SRM would be a perfect substitute for abatement and removal. Equation (2) would then simply match the marginal cost of adaptation with the social cost of carbon. In Figure 1a we have assumed this extreme special case for illustrative purposes: the extent of solar radiation management use is determined by the SCC. However, we cannot assume that it is a perfect substitute because, for example, it does not reduce ocean acidification. SRM also alters regional precipitation patterns. It is therefore only an imperfect substitute (Heutel et al., 2018).

This raises the question of the conditions under which CO<sub>2</sub> removal can be considered a game changer compared to the other options. Specifically, under what conditions will removal be preferred to SRM if cost reductions prevail in both sectors? To illustrate this, we assume that technological progress is equally high for both sectors and consider the change in the portfolio of climate policy, consisting of abatement, adaptation, and removal. A shift in the portfolio towards removal is advantageous in the case of a perfect substitute if (and only if) the marginal costs there rise more slowly than with SRM:

$$C_{AA}^A > C_{RR}^R \quad (3)$$

Determining the shape of the marginal cost functions is an empirical question that remains largely unresolved. Previous studies assume relatively flat but also increasing marginal costs for solar radiation management (Meier and Traeger, 2022). To take into account the social damage caused by SRM, which has not yet been comprehensively quantified, quadratic damages are often assumed (Moreno-Cruz and Keith, 2013; Belaia et al., 2021; Helweggen et al., 2019). It is important, however, that all social cost components must be taken into account, especially the termination costs. If stratospheric aerosol injection is discontinued due to a global crisis such as a pandemic or a major geopolitical conflict, the temperature rises sharply. Such a sudden surge in warming would have severe consequences not only for society but also for the Earth system, both of which would struggle to adapt to several degrees of warming within just a few years.

If SRM is considered an imperfect substitute for carbon removal, limiting its capacity to effectively mitigate climate damages, deployment may be minimal. To make this claim plausible, consider the following comparison between two scenarios. We assume a cost reduction shock of equal magnitude in either of the two sectors. Then, the optimal capacity of either SRM or CDR increases. From the simple model above, we can derive the condition under which the capacity increase in CDR is greater than the increase in SRM deployment. The condition is given by (4). The inequality shows that even if SRM costs are reduced, it will only be used more if marginal damages are steep, that is,  $D_{EE}$  is correspondingly high:

$$C_{AA}^A - \frac{D_{EE}C_{MM}^M}{C_{MM}^M + D_{EE}} > C_{RR}^R \quad (4)$$

In other words, solar radiation management is used moderately at best to mitigate the worst temperature damage, but does not play a major role in climate policy. Whether individual countries, or even the entire international community, will consider smoothing the temperature remains to be seen. Switzerland has spoken out in favour of a global commitment to SRM, the African Union rejects further steps in this direction, and China, India, and Russia have not yet developed a clear position on it (Biermann and Gupta, 2024). It is possible that some countries want to use it primarily as a threat to persuade the main emitters to act (McEvoy et al., 2024). So-called ‘free-drivers’ would hope to stimulate the formation of a coalition of ‘anti-drivers’, who would ramp up their mitigation efforts to avoid unilateral deployment of SRM by the free-drivers. The more heterogeneous the geographical distribution of the side-effects of SRM is, the more likely such a scenario becomes. In Section 5 we will return to the topic of international cooperation in greater detail.

#### 4 THE GREEN ZERO: HARD INTERTEMPORAL BUDGET CONSTRAINTS, INCREASING CLIMATE DAMAGES, AND EXPECTATIONS ABOUT TECHNOLOGICAL PROGRESS

In the static analysis, it was possible to clarify under which conditions the use of CO<sub>2</sub> removal is advantageous from the perspective of society as a whole and also under which conditions removal is preferred to solar radiation management if there is cost-reducing technological progress in both sectors. The question of the extent to which there will be an overshoot in temperature and emissions and when the compensation of this carbon debt should begin is still awaiting an answer. The static model framework can be made dynamic in a very simple way:

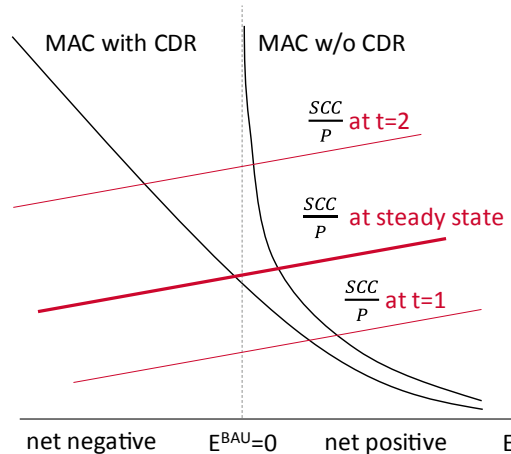
$$SCC(t) = P(t) \cdot MAC \quad (5)$$

Equation (5) extends equation (1) by a factor  $P$ , which acts as a parameter for technical progress: the marginal damage of climate change (SCC) must be equal to the effective marginal abatement cost. For our purposes, we can combine the abatement and removal sectors because we can assume that the more the marginal abatement costs (MAC) increase, the more the removal technologies will be utilised. In other words, if the Inada condition starts to bite in the abatement sector, removal will be increasingly utilised. We now distinguish between three phases of climate policy, which we can characterise using equation (5).

Figure 2 shows that the SCC is low in the first phase, while the net marginal abatement costs are relatively high. Thus, the curve  $SCC/P$  is rather low ( $t = 1$ ). As a result, positive net emissions are optimal. Positive emissions increase global warming, so the climate damage increases – that is, the SCC increases. At the same time, the marginal cost curve

of net abatement shifts downwards due to technical progress, and thus the  $SCC/P$  curve shifts upwards: climate policy becomes increasingly ambitious until emissions become net-negative in the second phase ( $t = 2$ ). Given sufficient net-negative emissions, the SCC can fall again until net zero is reached in a steady state.

FIGURE 2 OPTIMAL OVERSHOOT PATHS



Note: The faster the SCC rises and the faster the costs for CDR fall, the sooner net negative emissions are achieved.

Source: Authors' own illustration.

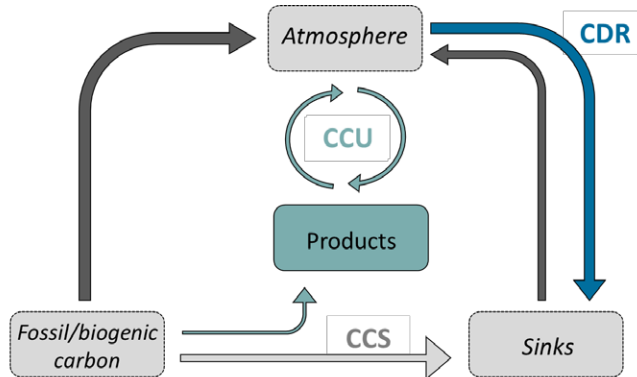
Without  $CO_2$  removal, this dynamic would not be possible – at best, emissions would slowly converge towards zero, but there would be no phase of negative net emissions. The more the SCC increases and the higher the expected cost reduction potential, the faster climate policy will enter the phase of net-negative emissions and the stronger the overshooting of the temperature target and emissions budget will be.

The third pillar of climate policy thus expands the scope of possibilities in two directions: it reduces the economic costs of climate policy, and it allows for more ambitious climate targets. This is made possible by greater sectoral and temporal flexibility. A temporary overshoot of the global carbon budget, and thus also the temperature, is offset by later compensation. From the perspective of a social planner, adherence to the intertemporal budget constraint is time-consistent if climate damages are considered. However, if the social planner applies cost-effectiveness analysis, time consistency is lost. It is then rational for the social planner to constantly postpone the repayment of the carbon debt because the flexibility gained does not incur any costs in the form of additional climate damages. Adhering to 'green zero' is therefore only a time-consistent policy if the damages caused by climate change are systematically recorded. This is another reason why the SCC damage metric should be used in climate policy in order to rationally enable compliance with an established carbon budget.

## 5 INDUSTRIAL MANAGEMENT OF THE GLOBAL CARBON CYCLE

CDR refers to a portfolio of technologies that provide technical or natural storage for carbon that has been removed from the atmosphere. However, these technologies should not be considered in isolation, but as part of the industrial carbon cycle as shown in Figure 3. Also part of the industrial carbon cycle are carbon capture and utilisation (CCU) and carbon capture and storage (CCS). The three sets of technologies are not distinct, but overlap to a certain extent. CCU involves capturing CO<sub>2</sub> emissions, typically from industrial processes, and using the captured CO<sub>2</sub> as a raw material for various applications such as manufacturing synthetic fuels and creating building materials. Some CCU applications also may be considered CDR, such as when captured carbon is stored in building materials. CCS technologies capture CO<sub>2</sub> emissions from point sources and store the carbon permanently in underground geological formations. Some CDR methods include CCS technologies, the most prominent examples being DACCS and BECCS. Direct air capture or bioenergy do not necessarily have to be used in conjunction with CCS; biogenic or atmospheric carbon can also be used in combination with hydrogen to produce synthetic fuels. These are then merely greenhouse gas-neutral, that is, they do not generate any negative emissions along their value chain.

FIGURE 3 THE INDUSTRIAL CARBON CYCLE



Source: Authors' own illustration, based on Gap (2022) and Smith et al. (2023).

The core task of the industrial management of the carbon cycle is to find a permanent or, as in the case of CCU, at least temporary storage alternative to the atmosphere for greenhouse gases, especially for CO<sub>2</sub>. So far, we have assumed that a permanent reservoir can be found. However, the various removal technologies differ not only in terms of their technical potential and costs, but above all in terms of their storage duration. It has been shown that it makes sense to also utilise non-permanent storage methods. Emissions released from non-permanent storage after a certain period must be addressed either through permanent removal or by renewing non-permanent storage methods. If replaced with permanent solutions, the carbon debt is eliminated. However, if compensated through further non-permanent removal, the carbon debt is only temporarily mitigated.

This necessitates the creation of new carbon reservoirs to replace those that have been depleted. The ongoing challenge of managing carbon debt resembles the myth of Sisyphus: humanity must either continually reduce its carbon debt or establish new reservoirs to sustain the cycle (Franks et al., 2024).

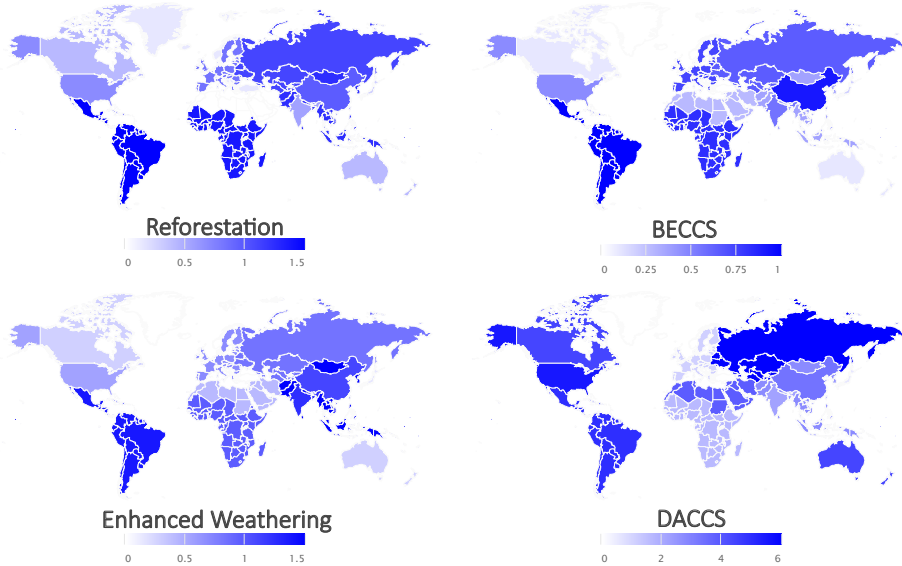
It is obvious that the economic value of non-permanent carbon sinks is lower than that of sinks that permanently store greenhouse gases. We can illustrate the difference in an exemplary calculation: with a discount rate of 2% and a storage period of ten years, such a carbon sink would only have 17% of the value of a permanent carbon sink. The social cost of carbon must be corrected by the factor  $r/r+\delta < 1$  (Franks et al., 2024). This correction factor accounts for those damages that arise in the future from carbon emissions that are released from the temporary storage back into the atmosphere. It also accounts for the costs of applying diligence in managing the non-permanent storage space. From a macroeconomic perspective, a certain amount of capacity for non-permanent CDR is nevertheless optimal, as the intertemporal costs can be smoothed. The use of non-permanent CDR options also makes sense if the permanent options are not yet available to a sufficient extent or are initially still too expensive.

Franks et al. (2024) also discuss the challenges of implementing optimal pricing instruments for incentivising non-permanent CDR. The regulator can use Pigouvian subsidies, either on the flow of removed emissions or the stock of stored carbon. Under downstream pricing, the removal subsidy equals the tax on released emissions, which corresponds to the social cost of emissions, SCCE. Alternatively, a storage subsidy can target the stock of stored carbon. By contrast, upstream pricing reduces the removal subsidy below the emission tax to implicitly account for expected future releases, based on the social cost of removals, SCCR, which depends on the release rate and discount rate. However, if diligence affects the release rate, optimal policy again requires monitoring release flows, making upstream schemes informationally equivalent to downstream ones. Thus, monitoring, reporting, and verification (MRV) is crucial for the regulator. Also, moral hazard can occur. Under downstream pricing, for instance, firms might incur long-run deficits and, being judgement-proof, externalise the social cost of carbon by defaulting strategically.

An overview of the removal options and their regional distribution can be obtained using scenarios from integrated assessment models, such as those calculated for our purposes using the REMIND model. As Figure 4 shows, a broad portfolio of options would be used by the end of the 21st century. The division of labour between the different regions results from the comparative cost advantages. Russia, for example, could benefit from the use of DACCS, as sufficient and inexpensive geological deposits are available here. BECCS would be an option for Latin America and Africa in particular. Reforestation is particularly advantageous in tropical regions, as more carbon can be stored per hectare

there than in the cooler northern regions; here too, Latin America, Africa and South-East Asia have the greatest potential. The availability of arable land in warm and humid regions is crucial for enhanced weathering, which is why India, China, and the Latin American continent have a comparative advantage in this regard.

**FIGURE 4 THE INTERNATIONAL DIVISION OF LABOUR FOR CDR**  
Regional CDR deployment in 2100 [Gt CO<sub>2</sub>/yr]



Note: Regional CDR use in 2100 (gigatonnes of CO<sub>2</sub> per year).  
Source: J. Strefler (PIK).

## 6 CDR AND INTERNATIONAL COOPERATION

International cooperation in climate policy is essentially failing because of the incentives to free-ride, and for two reasons: first, everyone benefits from individual countries' abatement efforts, which makes opting out of climate agreements attractive; second, unilateral abatement of emissions results in carbon leakage. Unilateral reductions of fossil fuel use lowers their prices and reduces unilateral abatement efforts because other countries can use the cheaper fossil fuels (Bohm, 1993).

Although the use of CDR does not eliminate all incentives to free-ride, it improves the Nash equilibrium and reduces the distance to the social optimum because its deployment does not reduce fossil resource prices. To illustrate this point, we proceed in two steps: first, we consider the case of symmetric countries; in the second step, we introduce net exporter countries and net importer countries of fossil fuels.

In principle, each country decides on its optimal division of labour between emission reduction and carbon removal. This takes into account not only the marginal costs of the various options, but also the extent of carbon leakage: the higher the carbon leakage rate and the lower the marginal costs of removals, the more the country will invest in removals. The decisive factor is that the efforts of all countries add up when it comes to removal, so that the distance to the social optimum is reduced.

What happens to international cooperation if a distinction is made between net exporters and net importers of fossil fuels? Increased investment in emissions abatement reduces the demand for coal, oil, and gas and therefore their prices. In this scenario, the net importing countries benefit, while the net exporting countries lose. The net importing countries therefore invest more in emissions abatement.

However, because the net exporting countries lose their resource rents as a result of this development, they have an incentive to invest more in carbon removal technologies, which increases the demand for fossil fuels. This is because in the transition to a climate-neutral economy, fossil fuels will also be used for removal technologies. As a result of the change in the terms of trade, net importing countries will lose, while net exporting countries will gain: the former will invest less in removal, while the latter will invest more. The terms of trade therefore drive a wedge between the price of removal and the price of emissions abatement. The net exporting countries subsidise CDR, while the net importing countries tax their fossil fuel imports, thereby appropriating part of the resource rent of the owners of coal, oil, and gas. However, the global level of ambition does not change compared to the symmetrical case; only the division of labour between exporting and importing countries is modified.

CDR does not eliminate all cooperation problems in international climate policy. There is still an incentive for each individual country to act as a free-rider, since the mitigation of climate damages is a public good. Three main classes of proposals are put forward in the literature. First, coalitions (climate clubs) could be formed to impose climate tariffs against free riders (Nordhaus, 2015; Lessmann et al., 2009). Second, such climate clubs could share technologies free of charge (Lessmann and Edenhofer, 2011). Third, international cooperation could be stabilised through the payment of transfers via a fund (Kornek and Edenhofer, 2020).

Another proposal involves using solar radiation management (SRM) as a means to stabilise a coalition of countries committed to reducing emissions. Unilateral deployment of SRM – by a ‘free-driver’ – creates externalities for other nations, such as disruptions to precipitation patterns. The hope is that this threat could incentivise the formation of a coalition of ‘anti-drivers’, who address the cooperation problem (McEvoy et al., 2024) by increasing their mitigation efforts to avert deployment. This dynamic is particularly likely in a heterogeneous international landscape, where the unevenly distributed impacts of SRM create strong incentives to prevent its use through enhanced emission reductions.

However, the success of this strategy depends on the affected countries having the option to respond by reducing emissions. If, instead, they find it more advantageous to adapt to the altered precipitation patterns, SRM could push the global community further away from an optimal balance between emissions abatement, adaptation, and removal. Given this risk, alternative mechanisms – such as climate tariffs, technology clubs, and international funds – may offer more effective pathways for stabilising international cooperation.

## 7 THE EU EMISSIONS TRADING SYSTEM AND GREEN ZERO

The European Union is an interesting laboratory for the future regulatory framework. The European climate targets require considerable investment in carbon removal. By 2050, just under 1% of European GDP could flow into CDR deployment each year (Edenhofer and Leisinger, 2024). Globally, the share would be 3%, assuming that up to 15 gigatonnes of CO<sub>2</sub> are removed from the atmosphere annually by 2050 (Edenhofer et al., 2024).

Based on the current situation, European emissions trading could have to be used to finance carbon removals. A success in this regard would also have a signalling effect to other regions of the world that are facing similar challenges and are planning to set up national emissions trading schemes

So far, the European Union has been discussing how net zero can be achieved in European emissions trading. The last certificate in the existing trading system for energy and industry will likely be auctioned in 2039 – and the residual emissions in some sectors, such as the cement industry, can in all likelihood only be avoided at extremely high cost. Prices could therefore rise dramatically in the 2040s if the possibility of offsetting these residual emissions through withdrawals is not created (Pahle et al., 2023; Sultani et al., 2024). As traders on the markets are already making investment decisions today and also hoarding certificates, the regulatory framework must be created soon.

To ensure that net-negative emissions can be generated in the EU Emissions Trading System (EU ETS), we therefore propose two reform steps (Lessmann et al., 2024). In a first step, a new type of certificate should be introduced – clean-up certificates. In a second step, a European Carbon Central Bank should be established to regulate the carbon markets.

The introduction of clean-up certificates enables the financing of net-negative emissions. Now, for each ton of CO<sub>2</sub> that firms emit, they face the choice between purchasing one conventional emission allowance or one clean-up certificate. Clean-up certificates are cheaper than conventional allowances, but the companies simultaneously incur a carbon debt that they will have to pay back at a later date. This is only a worthwhile option

for companies if they can expect the cost of carbon removals to be sufficiently low in the future; otherwise, it would be more cost-effective to invest in reducing emissions. If companies trust in technological progress, they will purchase the new type of certificate; if they do not trust in it, the option is not worth considering for them.

The regulator can implement the carbon debt in addition to the emissions reduction for the original carbon budget or as a means to allow a temporary overshoot of the carbon budget (or a mix of both). The former creates additional net-negative emissions that reduce the cumulative net emissions of the ETS below the initial carbon budget. The latter creates additional intertemporal flexibility and thus leads to falling prices in emissions trading. The latter way of implementation is akin to allowing emissions trading where not only banking but also borrowing is permitted.

The clean-up certificates framework can adapt to technological uncertainties while maintaining incentives for emissions reductions and carbon removal. The reason is that the ‘exchange rate’ between emission allowances and carbon debt in clean-up certificates does not have to be one, as introduced above; the exchange rate is a deliberate choice of the regulator and can be flexible, allowing for greater financing of removal technologies. An exchange rate greater than one means that for each ton of carbon emitted, more than one ton of carbon needs to be removed later. As technologies improve and costs decrease, the exchange rate can be adjusted to incentivise more ambitious removal targets. The maximum exchange rate and minimum long-term emissions target depend on the sum of the discount rate and the rate of cost-saving technological progress. When this sum exceeds a certain threshold, the ETS can finance carbon debt beyond the initial budget, enabling net-negative long-term targets. By linking the exchange rate to technological progress, clean-up certificates create a dynamic incentive for innovation in CDR technologies, potentially accelerating their development and deployment.

Time inconsistency, however, is a strong concern. To avoid the creation of carbon debts that remain unpaid in the future while simultaneously undermining emission reduction efforts, two safeguard mechanisms are required.

First, the European Commission must be able to reduce the amount of conventional certificates to a certain extent. Although individual companies have bought additional flexibility, the market as a whole cannot postpone the mitigation effort entirely into the future. A withdrawal of conventional certificates by the Commission that fully compensates for the issuance of clean-up certificates would be tantamount to tightening the climate target at constant carbon prices. Thus, industry, the Commission, environmental organisations and Parliament have some room for negotiation. It is crucial that the regulator be equipped with the option if it turns out that the climate damage is much higher – due to a higher climate sensitivity – and at the same time the potential for CDR is much more limited than expected (Schleussner et al., 2024).

The second safeguard mechanism addresses the default risk in cases of corporate bankruptcy. Companies should provide a security deposit (collateral) equivalent to their carbon debt, which would be held by a carbon central bank. If the carbon is physically removed from the atmosphere, the carbon central bank uses this deposit to repay the holders of security certificates. If removal does not occur, the bank retains the full deposit amount.

A critical feature of the system is the tradability of the securities. Once the company has paid the deposit, it can sell the security certificates on the market. Market dynamics will then determine their price based on factors such as technological progress and the company's credibility. The mechanism simultaneously creates demand for CO<sub>2</sub> removal solutions and ensures their financing. By holding security deposits, the carbon central bank serves as a lender of last resort, preventing the accumulation of unrepaid carbon debt and maintaining the integrity of the system.

If technological progress in removal technologies is sufficiently strong, we estimate a sizable welfare gain in the order of magnitude of the EU–Canada trade agreement. Moreover, if exploited to the fullest, we estimate that clean-up certificates could potentially enable a net-negative long-term targets for the ETS and finance up to 18 GtCO<sub>2</sub> of net-negative emissions until the end of the century (Lessmann et al., 2024).

## **8 CDR - A GAME CHANGER?**

The emergence of carbon capture technologies fundamentally changes climate policy. First, it reduces the costs of climate protection through increased sectoral and intertemporal flexibility, especially because it can also compensate for temporarily exceeding temperature targets. Conventional adaptation measures, but also solar radiation management, can be used to a limited extent, but lose importance compared to CDR – more so as the social cost of carbon increases and as the costs of CDR decrease. Second, the removal of greenhouse gases can increase international cooperation and thus create new political momentum in future climate negotiations. Third, we need to put carbon pricing on a new institutional footing so that net-negative emissions can be financed without additional tax revenues. At the European level, this can be achieved through the introduction of new types of clean-up certificates and the establishment of a European Carbon Central Bank (ECCB).

Johann Heinrich von Thünen (1783-1850), who gave his name to the lecture series on which this chapter is based, was not only one of the forefathers of general equilibrium theory (Samuelson, 1983). He was also one of the first economists to warn against the overexploitation of local common pool resources (Nellinger, 2014). He was already anticipating key insights that Elinor Ostrom analysed 160 years later in her book, *Governing the Commons* (Ostrom, 1990). Climate change poses a significant threat to global commons – such as the atmosphere, soils, oceans, and forests – bringing them to levels of overexploitation unprecedented in the entire history of the Holocene.

Von Thünen proposed measures to prevent the overexploitation of local fish stocks, for example. He was concerned with securing the prosperity of 19th-century Mecklenburg. The application of his insights and proposals, which he developed for local common goods, poses a major challenge for the utilisation of global common goods: over the next 26 years, a quarter of today's emissions are to be removed from the atmosphere and stored in geological formations (UNEP, 2023a; Smith et al., 2024). CDR technologies are not niche technologies. The development of a planetary waste disposal system presents mankind with an enormous task that will serve to secure the future prosperity of humankind. In this chapter, we have outlined and evaluated feasible, but at the same time courageous, steps towards this goal.

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# Designing and scaling up nature-based markets

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## 1 SETTING THE STAGE

The natural carbon cycle provides a critical lever to fight climate change. Overall, the biosphere is a net carbon sink (Rockström et al., 2021). Carbon sequestration in plants and soils currently absorbs around 4.8 Gt of CO<sub>2</sub> annually (Friedlingstein et al., 2023). By some estimates, it could contribute 37% of cost-effective emissions reductions through 2030 (Griscom et al., 2017). This has not landed on deaf ears. According to Grassi et al. (2017), land use and forests made up a quarter of the emissions reductions planned under the nationally determined contributions (NDCs) submitted by signatories of the Paris Agreement.

Nature is also a carbon stock. Natural forests cover 28% of global land cover and non-natural tree cover represents 2%. Carbon stored in all forests (accounting for all carbon pools – living biomass, dead wood, litter, soil organic matter and harvested wood products) is estimated to represent 870±61 Gt of carbon, of which tropical forests represent 54% (Pan et al., 2024). Preserving these forests is, therefore, essential. Emissions from deforestation are estimated to release around 7 Gt of CO<sub>2</sub> per year, cancelling and reversing the carbon absorbed through afforestation and reforestation (Friedlingstein et al., 2023).

But nature's services go well beyond climate change mitigation. The Dasgupta Review emphasised that economies and livelihoods are deeply dependent on nature, which should be recognised and valued as an asset (Dasgupta, 2021). Costanza et al. (1997) estimated the value of the ecosystem services the biosphere provides at one to three times

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global GDP. This initial estimate was then updated and refined, with an estimate of the loss of ecosystem services due to land-use changes (Costanza et al., 2014). Forests provide a habitat to more than half of the world's land animal and plant species and are a direct source of food, income, and shelter for millions of people.

This chapter explores options to scale up market-based solutions to finance and support the provision and conservation of nature's essential services. It starts by describing the inputs to the problem at hand (Sections 1 and 2) before discussing current credit-based solutions and their shortcomings (Section 3). Section 4 describes our new share-based market design for nature-based provision. Section 5 discusses how it can be adapted to nature conservation.

### 1.1 What's special about nature?

The services that nature provides differ in many ways from the manufactured products, commodities, and assets traded in most markets. These differences create challenges but also opportunities when it comes to designing markets based on nature.

First, nature comes as a bundle of functionally linked and interdependent goods and services. Carbon storage and sequestration are just two of these services. Biodiversity is a key attribute of natural ecosystems as it contributes to their resilience and, therefore, supports many of the other services that nature provides.

Relatedly, ecosystems are highly multidimensional. Their description requires a large number of indicators measured at different scales. For example, biodiversity is defined at multiple levels: genetic, species, population, ecosystem, and functional ecosystem. It is common for nature management interventions to improve some metrics of biodiversity or ecosystem service provision but degrade other metrics. Focusing on a simple single indicator, such as species abundance for biodiversity, may be misguided and lead to scientifically unsound interventions. Appendix 1 gives an overview of the most popular single indicators.

Currently, there is no commonly agreed measure of biodiversity. The verification community and standard setters are working on establishing a consensus. The emerging consensus seems to be a composite indicator that combines a matrix of quality attributes with areas to produce an indicator of 'quality hectares'. Verra's Nature Framework, for instance, defines nature credits using three dimensions – 'extent', 'condition', and 'significance' – to capture both the physical area involved in projects and the ecological quality of habitats.<sup>2</sup> By multiplying 'extent' and 'condition', Verra computes quality hectares, a unit designed for comparability across different sites.

2 See <https://verra.org/methodologies/nature-framework/> (accessed on 10 March 2025).

Second, natural ecosystems are intrinsically dynamic and subject to shocks and variations. State variables of natural ecosystems vary due to multiple factors, both external and internal. External factors include climate variability. Internal factors include processes such as vegetation successions. Other processes of change, such as wildfires, combine both internal factors (i.e., fuel accumulation) and external factors, such as dry conditions causing increased flammability and sources of ignition (thunderstorms or human activities). These dynamics are non-linear and display threshold and hysteresis effects. Some of these changes may be irreversible – for example, when species become extinct. Changes in natural ecosystems are also caused by human activities, primarily through land use changes and pollution. Some of these changes are intentional (e.g., forest clearing for agriculture), while others are unintentional and result from spillovers associated with other human activities taking place in other places or sectors.

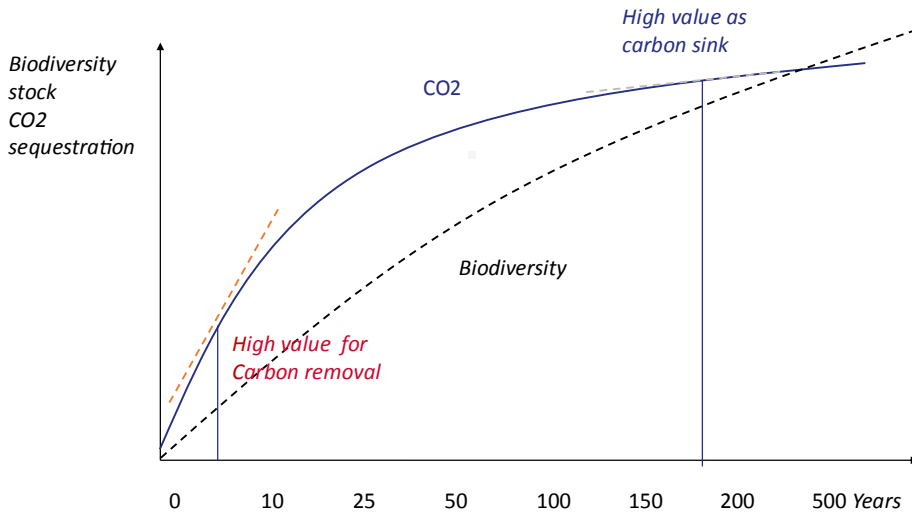
Combined with nature's multifunctional character, these complex dynamics mean that attribution of the causes of change in an ecosystem can be challenging. These causes may be climatic (e.g., drought), biophysical (e.g., wildfires, pests, invasive species, natural successions), related to human intervention, or a combination of all these factors.

Third, the functioning of natural ecosystems differs greatly across geographies and eco-climatic zones. Each geographic region has a specific regime of disturbances to which natural ecosystems are functionally adapted. As a result, ecosystems are not equivalent across geographies. A loss in a lowland tropical forest cannot be compensated by a gain in a highland tropical forest, for example.

Because natural ecosystems are living systems, time plays an important role. The time scale for ecosystem restoration or rewilding is very long; it takes decades to achieve significant biodiversity gains through ecosystem restoration. This restoration time can be somewhat shortened by an active reintroduction of species. Still, the slow biological cycles need to be integrated to avoid negative cascading effects that could result from a programme of nature restoration that is rushed and creates transient ecological imbalances (for example, in prey–predator equilibriums). In contrast, large carbon sequestration can happen quickly following reforestation or afforestation, even if forests and their soils continue to absorb carbon for hundreds of years (Luyssaert et al., 2008).

Figure 1 illustrates schematically these different stock-flow dynamics for carbon and biodiversity. A young, naturally regrowing forest is highly effective at removing carbon from the atmosphere (CO<sub>2</sub> flow). However, its biodiversity stock is relatively low. In contrast, a mature forest hosts a high stock of biodiversity but is less effective at removing carbon because, in a mature forest, new biomass growth (which sequesters carbon) is increasingly balanced by decomposing biomass (which releases carbon). At the same time, a mature forest serves as a valuable reservoir for long-term carbon storage (CO<sub>2</sub> stock). While an individual tree is not a permanent carbon store, a mature forest ecosystem maintains its carbon stock as dying trees are continuously replaced by new growth. In other words, young forests are valuable for their carbon flow, whereas mature forests are valuable for both their carbon stock and the biodiversity they sustain.

FIGURE 1 STYLISED AGE PROFILE OF CARBON AND BIODIVERSITY STOCKS IN A FOREST



## 1.2 Challenges specific to the Global South

The Global South, which hosts a large portion of existing forests and offers great potential for further carbon sequestration and biodiversity conservation, brings further challenges for nature-based markets. A large share of rural populations in the Global South depend directly on farming for their livelihoods. They also directly rely on nature for the provision of a range of essential ecosystem goods and services, such as drinking water, biomass for fuel, and wood for construction.

Despite this dependence, rural populations in the Global South often suffer from a lack of secure land rights and unclear rules for land ownership and access to natural resources. It is common to observe overlapping systems of access rights, with conflicting customary, public, and private land tenure systems regulating the same agricultural and forest lands.

Some of these countries also suffer from syndromes associated with 'weak states'. This poses specific challenges for the design of nature markets as, where poor governance and corruption are prevalent, the risk is high that financial resources aimed at promoting nature conservation are seized by intermediate public or private actors before these resources reach the local land managers most in need of them, typically rural and Indigenous communities.

Most countries in the Global South have experienced in their history a colonial regime for extended periods of time, with the associated appropriation and extraction of their natural resources. This history leads to great sensitivity to any form of land or resource 'grabbing', even for nature conservation. As a result, some countries have enacted legislation to exclude foreign actors from acquiring land with valuable natural resources.

The expression ‘green colonialism’ includes mechanisms to expand nature conservation for the development of projects related to carbon and biodiversity markets. Any market design must account for this sensitivity to avoid being undermined by local regulations and actions.

### 1.3 The landscape for climate and nature-positive solutions

Nature-based solutions have become a catch-all term for different approaches that rely on nature and seek to foster the provision of climate and/or biodiversity benefits or avoid adverse climate or biodiversity impacts. These approaches differ in the mix of biodiversity and climate benefits they offer and the counterfactual used to assess these benefits. Understanding these differences is essential for sound market design.

Figure 2 maps these different approaches according to their climate and biodiversity benefits. In the top-right corner are solutions that generate both climate and biodiversity benefits. This category includes natural reforestation, revegetation, mangrove restoration, and regenerative agriculture. These approaches not only remove carbon from the atmosphere but also enhance biodiversity by restoring ecosystems (Ren et al., 2020; Wu et al., 2021; Andres et al., 2022).<sup>3</sup> Carbon extraction, however, does not always enhance biodiversity. For example, fast-growing monoculture plantations based on exotic species (often eucalyptus or pine trees) can sequester carbon efficiently but provide limited biodiversity benefits. Figure 2 captures this diversity by the large span of biodiversity benefits associated with nature-based provision of climate and biodiversity benefits. When biodiversity benefits are very low, these nature-based solutions are close to technology-based carbon removal solutions such as direct air capture (in blue in the figure).

The second group of approaches seeks to avoid the destruction of existing ecosystems. These are represented in the top-left corner of Figure 2. Conservation projects protect existing forests and other ecosystems against destruction, thus preventing massive releases of carbon. Depending on the state of maturity of these ecosystems, they can also generate climate and biodiversity benefits above and beyond their existing stock. For example, a young forest will continue to grow, absorbing carbon and expanding its support for biodiversity. These climate benefits will typically be lower than reforestation/afforestation and restoration projects because their growth rate is lower.

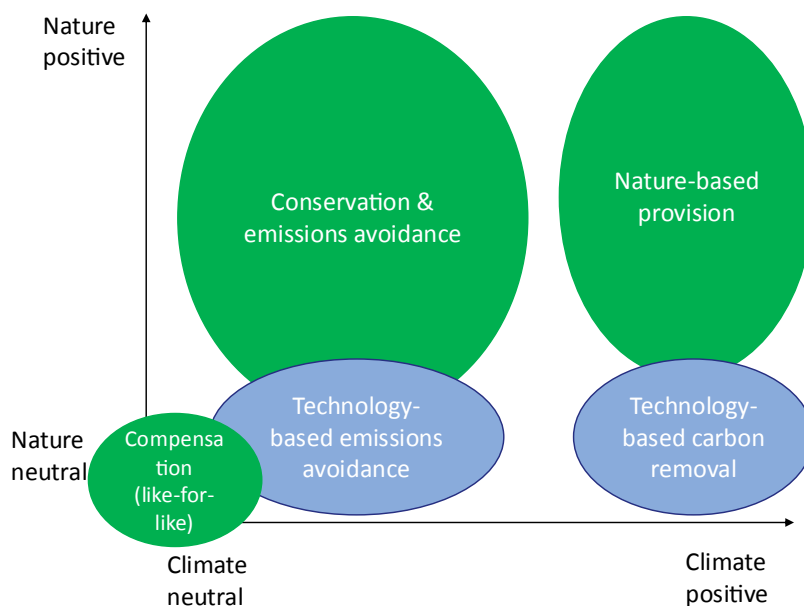
Similarly to conservation projects, nature-based emissions avoidance projects seek to avoid the destruction of existing ecosystems. They do so by providing local communities with viable alternatives to deforestation (such as agroforestry) or by promoting forest management practices (such as fire prevention) that reduce emissions relative to the

3 See <https://www.worldwildlife.org/initiatives/mangroves-for-community-and-climate> (accessed 18 February 2025).

status quo. As for conservation, the associated biodiversity benefits range from small to large. They are complemented by technology-based emissions avoidance solutions, such as efficient household cookstoves, waste recovery for energy production, or carbon capture and storage (CCS). These technology-based solutions are represented in blue.

A third group of nature-based approaches, which we label compensation, seeks to compensate for unavoidable environmental degradation in one area – due, for example, to infrastructure development – by restoring nature in another, equivalent, area. They are part of a broader set of measures to mitigate environmental degradation due to land use changes. These schemes typically follow a hierarchy of actions: first, avoiding environmental harm where possible; second, implementing measures to reduce residual impacts; and finally, compensating for any remaining, unavoidable losses (IAPB, 2024). By design, compensation seeks to be at least biodiversity-neutral, meaning that nature is restored in an area sufficiently similar to the area where the environmental degradation takes place (referred to as the like-for-like principle).

FIGURE 2 AN INTEGRATED FRAMEWORK FOR CARBON AND NATURE-POSITIVE SOLUTIONS



Our chapter focuses on nature-based provision and conservation. We deliberately exclude technology-based carbon removals and climate solutions from the scope of our analysis (for a treatment of these solutions, see Chapter 7 in this volume by Edenhofer, Kalkuhl and Franks and Edenhofer et al., 2023). We also leave compensation schemes aside and don't cover them because they tend to be local by design and, therefore, are less relevant for scaling up finance for climate action in the Global South.

## 2 PROVISION VERSUS CONSERVATION AND THE RATIONALE FOR EXTERNAL FINANCE

Nature-based provision and conservation not only differ in their mix of climate and biodiversity benefits and stock-flow dynamics; they also differ in their economics. The main issue with nature-based provision is that only a small share of the benefits generated by reforestation and nature restoration accrue to the owner of the natural resource or the local community. The other benefits are positive externalities. This is a classic public goods problem. In particular, the climate benefit of reforestation and nature restoration is a global public good, given that they absorb CO<sub>2</sub>, a global pollutant, from the atmosphere. This implies that, without external finance, resource owners and local communities have too little incentive to provide these services. The policy goal for provision, therefore, is to foster the provision of nature-positive carbon sinks.

Conservation of existing natural resources is different. The main issue here is that the benefits that owners and local communities derive from existing forests and land may be smaller for them than the economic benefits of reallocating the land to other uses, such as mining, agriculture, or animal rearing. This benefit constitutes an opportunity cost for landowners and local communities and implies that, without external finance, they are tempted to harvest the natural resource and convert the land to another use. The policy goal for conservation is to ensure that existing ecosystems are preserved to avoid massive carbon releases and the destruction of biodiversity.

The cost structure of these two activities is also different (Table 1). Reforestation and nature restoration require an upfront investment, with most of the climate and biodiversity benefits accruing over the following decades. By contrast, conservation involves recurring costs in the form of maintenance, protection against illegal harvesting and possibly compensation to landowners. As illustrated in Figure 1, the flow benefits from conservation depend on the area that is preserved, and in particular its level of maturity.

**TABLE 1 COMPARISON BETWEEN THE ECONOMICS OF NATURE-BASED PROVISION AND CONSERVATION**

	<b>Provision</b>	<b>Conservation</b>
Policy goal	Encourage the provision of nature-based carbon sinks	Avoid the destruction of existing ecosystems
Rationale for external finance	Carbon sinks are global public goods (positive externality)	Conservation represents an opportunity cost but deforestation generates a global public bad
Structure of costs and benefits	Investment precedes the benefits that accrue over a long period	Recurring costs, limited flow benefits

### 3 CHALLENGES WITH EXISTING MARKET SOLUTIONS<sup>4</sup>

Existing nature-based markets find their origins in the clean development mechanisms (CDMs) and Joint Implementation (JI) projects introduced by the Kyoto Protocol. CDMs involve investments in emissions reduction or carbon removal projects in developing countries. JIs are their equivalent for projects in developed countries. Both mechanisms are project-based and lead to the issuance of a credit recognising the emissions reduction or carbon removal associated with the project. Signatory countries could use them to meet their emissions reduction commitment under the Kyoto Protocol.<sup>5</sup>

Current carbon and biodiversity markets build on the template set by the CDMs and JI mechanisms. They are also project-based. Several independent organisations have profiled themselves to set standards for what counts as an eligible project and how carbon and biodiversity benefits are computed. They coexist alongside public international, national, and regional crediting mechanisms.

Additionality, permanence, baseline accuracy, and traceability are central criteria in all standards. *Additionality* means that the project would not have happened absent external funding. *Permanence* requires that the benefits from the project are permanent. This condition is especially demanding for nature-based projects given the risks of wildfires, pests, and other hazards impacting any natural resource. *Baseline accuracy* refers to the correct estimation of the counterfactual outcome absent the project. It ensures that the benefits of the project are properly quantified. This includes accounting for any leakage whereby the project displaces, but does not prevent, nature-harming activities. Finally, *traceability* ensures that the benefits generated by a project are not claimed twice. This is done through registries that record credits, verified benefits generated, and retirement (the use of the credits for compliance or offsetting).

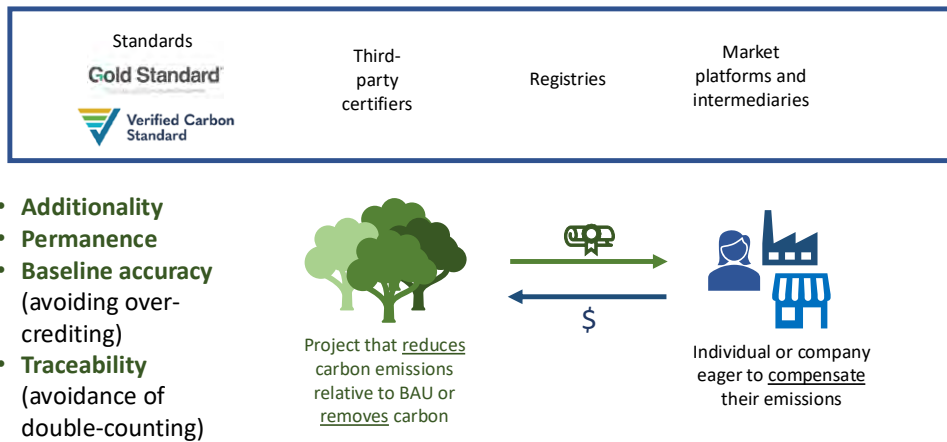
Projects are diverse: some are based on nature and others on technology. Nature-based projects can focus on climate benefits, biodiversity benefits, other ecosystem services (e.g., water cycling, soil protection), or any combination thereof. Some reduce emissions relative to a business-as-usual situation (avoided emissions), others physically remove carbon from the atmosphere (carbon removal). Reforestation and nature restoration are examples of nature-based carbon removal projects. Conservation can count as a nature-based emissions avoidance project if the case is made that the forest would likely be converted or degraded without funding.

4 This section draws from Cantillon and Slechten (2024a).

5 See <https://unfccc.int/process/the-kyoto-protocol/mechanisms> for more details (accessed 2 February 2025).

Credits are sold directly by project developers, standard-setting organisations, or independently run trading platforms. Buyers include companies, organisations, and individuals eager to offset their emissions. Additionally, some carbon credits are eligible for carbon emissions compliance schemes such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSA) or California's cap-and-trade scheme. Figure 3 illustrates.

FIGURE 3 THE ECOSYSTEM OF VOLUNTARY CARBON MARKETS



The voluntary carbon market makes up for the bulk of the issuance and trading. Liquidity and transparency are low. Prices vary largely according to projects, reflecting both the quality of the credits issued and the co-benefits of the projects. For example, carbon removal credits tend to trade at a higher price than carbon avoidance projects because the baseline is more certain and over-crediting less likely. Likewise, credits offering co-benefits beyond carbon and recent vintages trade at a premium (World Bank, 2024). Total transaction costs, including certification, monitoring, reporting, and trading, are large and are absorbed by intermediaries that are only service providers. Total transaction costs of the order of 40% of the sale price are common, leaving little for the local project developers.

Several scandals have shattered buyers' confidence in the voluntary carbon market. Researchers have documented the absence of additionality of projects (Schneider, 2009; Calel et al., 2021), large and systematic over-crediting of the benefits generated (Haya et al., 2020; West et al., 2020; Badgley et al., 2022; Gill-Wiehl et al., 2023) and leakage (Heilmayr et al., 2020). These concerns were further publicised when a syndicate of investigative journalists reported in January 2023 that more than 90% of rainforest carbon offsets certified by Verra, one of the largest standard setters, did not represent

genuine carbon reductions.<sup>6</sup> If this was not enough, a number of large-scale forest fires in 2023 and 2024 destroyed forests planted through carbon offset projects, cancelling all the claimed (and sold) climate benefits. In 2024, the Science-Based Target Initiative carried out a stock-taking exercise on the use and effectiveness of carbon credits. The Initiative concluded that the existing evidence pointed to their ineffectiveness in delivering their intended mitigation outcome (SBTi, 2024).

These concerns about credit quality and integrity have led to large drops in prices, especially for nature-based credits. Several initiatives are underway to promote and rebuild trust, including a revision of certification standards and government-sponsored crediting mechanisms (World Bank, 2024). These initiatives tend to raise standards for project qualification and governance. Some also address concerns about greenwashing on the demand side by developing guidelines for when using credits is legitimate as part of an organization's environmental strategy. This will improve the integrity and trust in the market, but is likely to come at the expense of large costs and therefore smaller scales. More importantly, these efforts do not address the issue of impermanence of nature benefits.

## 4 A NEW MARKET DESIGN FOR NATURE-BASED PROVISION

### 4.1 Overview

Our proposal rests on four building blocks: (1) a jurisdictional approach on the supply side; (2) a move from credits to shares that generate carbon and biodiversity dividends as the main asset to be traded; (3) a primary market organised as a crowdfunding market; and (4) a largely public governance of the market.

Jurisdictional approaches differ from existing approaches in that they operate at the scale of a jurisdiction (state, province, region) rather than at the level of a plot of land or farm. They work through a formalised collaboration between governmental entities and actors of civil society and/or the private sector, based on practices and policies intended to apply to all affected stakeholders in the jurisdiction (von Essen and Lambin, 2021). In so doing, jurisdictional approaches acknowledge the government's critical role in monitoring, enforcing, and regulating land use. They are used in sustainable commodity production ('eco-certification') and as part of the United Nations REDD+ scheme.<sup>7</sup>

6 <https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe>

7 REDD+ is a United Nations-sponsored framework that seeks to protect forests in developing countries from deforestation and degradation through methodological and financing guidance (see <https://www.un-redd.org/about/about-redd>).

Jurisdictional approaches provide a number of advantages (von Essen and Lambin, 2021). First, their inclusive governance fosters greater buy-in and provides for a more holistic approach. Second, their larger scale and their alignment with the monitoring, enforcement, and regulatory levels reduces selection issues and leakage, and improves baseline accuracy.<sup>8</sup> For these reasons, the additionality of jurisdictional-level projects is likely to be higher: all actors within the jurisdictions commit to the adoption of more sustainable resource use practices, rather than just the actors who would have adopted such practices anyway. This also eliminates the risk of intra-jurisdiction leakage. Finally, the larger size of jurisdictions means that the fixed costs associated with the monitoring, reporting, and verification cycle are spread over a larger base.

Our second building block concerns what is being traded. We propose that what is sold are not credits that recognise a flow benefit but instead shares in a nature-based provision project. In other words, buyers are investors. Their shares give them a right to carbon and biodiversity dividends, the currency of which is physical units (tCO<sub>2</sub> and change in quality × ha or any other relevant metric to measure biodiversity benefit). They can use these to claim climate and biodiversity contributions.

Shares in projects differ from credits in at least two important respects. First, credits are transactional – a company can buy a credit from a project one year and not the other. Instead, shares instil a longer-term perspective in investors, who will be willing to encourage sustainable forest management even if this decreases the rate at which carbon and biodiversity benefits are generated. Shares increase the commitment to the sustainability of the project and minimise the risk of an exclusive focus on quick, short-term gains. The shareholder has incentives to preserve the value of the asset, and thus the permanence of the project. Second, unlike credits, dividends do not need to match the flow nature benefits of the project, year on year.<sup>9</sup> Very much like profits for corporations, flow nature benefits can be kept in the project as provisions for future unexpected shocks. If the accumulated nature benefits are at risk because of changes in climate or the biophysical environment, prudence requires that dividends are distributed parsimoniously. This addresses the intrinsic non-permanence of forests and other natural ecosystems.

Our third building block is the design of the primary market. The primary market refers to the market where shares in provision projects are first sold by jurisdictions. A challenge here is that projects – like the nature that underlines them – are highly multi-dimensional. The fact that what is traded is a share (i.e., a stock) rather than a credit (i.e., a flow) adds a time dimension to an already complex bundle of attributes. We propose to organise this primary market along the lines of equity crowdfunding marketplaces.

8 Note that not all nature-based initiatives proposed by jurisdictions have to cover the entire territory of these jurisdictions. There can be exceptions as, for example, in the case of the restoration of mangroves or peatlands which are very localised.

9 Note that a current practice in the voluntary carbon market is to allow for a buffer whereby the number of credits issued is lower than the estimated carbon sequestration. This practice is similar to provisioning.

Jurisdictions list large-scale projects, described qualitatively and using a number of pre-defined descriptors that capture the project's social, environmental, and governance quality (see Appendix 2 for an illustrative list), with a requested minimum funding amount needed to carry them out. Investors decide how to allocate their funds across the listed projects. If a project attracts more funds than requested, the share price of this project increases until supply is equal to demand. If a project attracts less funds than requested, it is removed from the market, providing an opportunity for investors to reallocate their funds. The primary market clears when all remaining projects are funded.

This design leverages the competition between jurisdictions to promote the additionality of the projects funded. It encourages them to adopt and describe credible measures to increase the attractiveness of the project for investors, i.e., to avoid adverse social impacts, manage risks, prevent leakage, ensure permanence, and so on. The design also leverages the competition between investors and the price formation process to aggregate market preferences over project attributes. The primary market is complemented by a secondary market to ensure that investors who need to reallocate their funds can exit the market by reselling their shares.

Our final building block is market governance. Today, the voluntary carbon and biodiversity markets are largely privately governed. With some exceptions, standards are produced by private organisations, credit registries are maintained by private organisations, and marketplaces, when they exist, are run by private organisations. This contributes to their fragmentation and opaqueness and is part of the reason why transaction costs are so high. The inherently diverging interests of standard-setting organizations, certification bodies, and project developers undermine trust in the integrity of credits. We propose to replace this private market governance with a largely public and international market governance that sets minimal eligibility criteria for projects, define monitoring, reporting, and verification (MRV) protocols, organises the primary market, maintains registries, and provides public guarantees for projects. This will address today's market fragmentation and reduce transaction costs as a result.

## 4.2 Details

Our proposal differs most sharply from existing approaches in the proposed asset design and market mechanism, and it is worth detailing what these entail and their implications.

Consider asset design. The move from nature credits to nature shares that produce dividends not only changes the time horizon of investors, it also changes the time and risk profile of the asset traded. In the existing credit-based market, project developers invest upfront but only recover their investment costs over time as the project produces credits. They entirely bear the risk that climatic or biophysical events destroy their forest

or natural resource. Buyers of credits do not bear any of these risks. At most, they may bear some reputational risk if it is found that the credits they bought no longer represent climate or biodiversity benefits because a fire or another natural hazard destroyed the forest.

Our share-based asset design changes this time and risk profile. First, project developers – here, jurisdictions – get the funding upfront at the end of the primary market. In other words, the timing of funding aligns with the timing of their main costs. Second, production risk – i.e., the risk that the climate and biodiversity benefits do not materialise as expected – is now borne entirely by investors. In principle, there is no reason to expect that investors are more or less risk averse than jurisdictions and so no reason to worry about this transfer of risk, except if project developers have an influence on the production of climate and biodiversity benefits. As described in Section 1.1, this is partially the case. If so, the share-based asset design introduces the risk that project developers do not take all necessary measures to deliver sustained carbon and biodiversity benefits (moral hazard).<sup>10</sup>

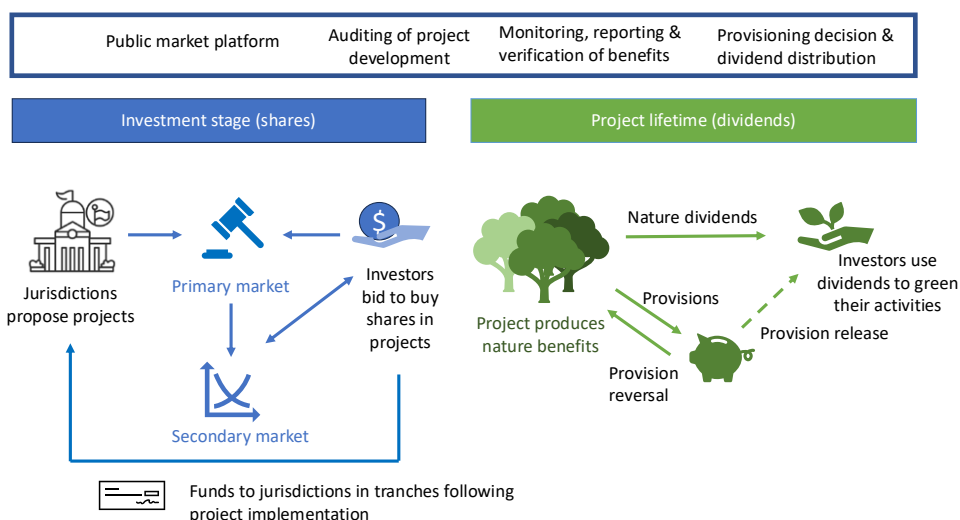
As time passes, the project produces climate and biodiversity benefits that eventually generate climate and biodiversity dividends. Given the non-permanence of nature-based benefits, prudence should apply when releasing these benefits in the form of dividends. Some of these benefits should be kept as provisions for future shocks. They accrue to the shareholders, who can use them to claim climate and biodiversity contributions. We see little value in making these dividends transferable, the way carbon credits today are, and thus in organising a market for them. The value of the investment in shares should be to receive these nature-based dividends, not to sell them. Investors who no longer see benefits in these nature-based dividends can sell their shares.

Consider next the market design. A particularly tricky part here is the multi-attribute character of the projects in which shares are offered. There is no such thing as an apple and an apple. Each project is unique in its combination of attributes. This is why we propose that jurisdictions describe their projects both qualitatively and using several pre-defined indicators that capture the social, environmental, and governance quality of the project. In that way, specific projects can appeal to investors with specific interests in an ecosystem (tropical forests, mangroves, mountains, etc.), an environmental issue (conservation of birds, seashores, soils, etc.), a geographic area (the Amazon basin, the Himalayas, the African savannas, etc.), and/or a category of actors (indigenous groups, smallholder farmers, livestock herders, etc.).

10 Another potential source of moral hazard is that the project developer takes the money and does not develop the project at all. The fact that jurisdictions are the project developers or at least project sponsors, reduces this risk.

Despite this diversity, there is a role for a market or, more precisely, for competition between jurisdictions offering projects to be funded and investors bidding on projects. In our proposed design, jurisdictions post a minimum funding cost for their projects, below which the project cannot take place. This is non-negotiable. Jurisdictions cannot reduce their minimum ask price if demand for their project is insufficient. On the other hand, if demand exceeds the number of shares available at that ask price, the price is adjusted upward until demand equals supply. These features together are useful for two reasons. First, because prices can go above the minimum ask price, jurisdictions have no incentive to inflate their minimum funding costs. An ask price above what is needed for the project can only result in the project not being funded, even if there would be sufficient demand for the project at its actual cost. This encourages additionality. Second, when demand exceeds the funding needs, the equilibrium price reveals information about how investors value the bundle of attributes that the project offers.

FIGURE 4 THE ECOSYSTEM OF NATURE-BASED EQUITY MARKET



Ensuring a liquid secondary market is important given that the asset is a share and not a credit (flow benefit). Without one, investors would be stuck with their investment and unable to exit if their circumstances change. This would reduce the attractiveness of the primary market. There are lessons to be learned from both the failure to establish a liquidity market for carbon credits and the design of secondary markets for treasury bills. The voluntary carbon market is illiquid because buyers care about the quality of the credits they buy. Attempts by exchanges to standardise and bundle credits that meet specific requirements have met resistance from market participants eager to avoid adverse selection – paying the price of a peach but instead getting a lemon (World Bank, 2023). Treasury markets face a similar problem: treasury bills come with different remaining maturities. Organising one market (and thus one price) for each remaining

maturity would result in low liquidity. But they have overcome this problem. Treasuries of different maturities are sold in a single market, and a pre-agreed conversion factor is applied to the price whenever the delivered treasury bill departs from the benchmark one. We propose to do something similar, by leveraging the information generated in the primary market about investors' preferences. Specifically, for those projects that sell at a higher price than the minimum ask price, the primary market generates prices for each bundle of attributes.<sup>11</sup> We can use this information to generate conversion rates between projects within project categories, and organise a market for each project category. By construction, investors should be (nearly) indifferent about receiving any of these shares once the conversion rate is applied.

Figure 4 illustrates our proposed new market design. Because the asset traded is a share, and not a credit, we need to distinguish the investment stage from what happens during the lifetime of the project. At the investment stage, investors can buy shares in the primary market where jurisdictions offer their projects for funding. These funds may be distributed in tranches, following project implementation and to pay for conservation. In parallel, a secondary market for shares is organised to allow investors to sell their shares or buy from other investors. The outcome of the primary market is used to generate conversion rates between shares in different projects and therefore ensure sufficient liquidity in the secondary market. During its lifetime, the project produces carbon and biodiversity benefits, some of which are distributed as nature dividends, while others are kept with the project as provisions against future shocks. Some of these provisions may be distributed later. Investors may use the nature dividends they receive to offset the nature impact of their activities.

### **4.3 Advantages of the new design relative to existing credit-based approaches**

We now argue that our proposed design addresses many of the issues existing credit-based approaches face. We have already argued that competition between jurisdictions in the primary market encourages them to quote a minimum ask price that corresponds to their costs of carrying out the project. If a project is not additional, i.e., if it would take place even in the absence of external funding, then a jurisdiction should in theory quote a zero price for that project. Note that it does not mean that all projects will be funded at the least cost since the price is allowed to increase in case of excess demand. That's the sacrifice we must pay to ensure that the market performs two roles: fostering additionality and aggregating preferences over project attributes.<sup>12</sup>

<sup>11</sup> Technically speaking, this is done using a hedonic regression of equilibrium prices on project attributes.

<sup>12</sup> In fact, one may argue that the prospect of getting more than what was asked can create a virtuous circle where jurisdictions have an incentive to propose projects with a bundle of attributes that are attractive to investors.

The close alignment between the project and administrative boundaries of jurisdictions reduces leakage relative to credits based on smaller projects. Likewise, we can also expect the large project size to reduce the costs linked to certification and the monitoring–reporting–verification cycle since most of these costs are fixed.

Our design offers a chance to aggregate investors’ preferences over project attributes and therefore generate a price for each attribute. Not only does it facilitate the development of a liquid secondary market; it also avoids the current situation where the currency for credits is a ton of CO<sub>2</sub>, but they sell at different prices based on a subjective evaluation of the reputational risk associated with different sources of credits. In the new design proposed here, shares in projects will sell at different prices the same way different stocks sell at different prices, based on objective attributes that are made explicit. The implicit price for the carbon and biodiversity benefits they generate will be the same. Last but not least, our design instils a long-term perspective in what is largely today a transactional market.

**TABLE 2 COMPARISON BETWEEN EXISTING CREDIT-BASED APPROACHES AND OUR SHARE-BASED MARKET DESIGN**

	<b>Existing credit-based approaches</b>	<b>Proposed nature shares design</b>
<b>Nature impermanence</b>	Not accounted for or minimally so (one credit = one unit of flow benefit). No financial interest of buyer of credits to invest in long term permanence of nature benefits	Prudent policy of dividend release accounts for the risk of impermanence. Moreover, investor is financially interested in prudent management of natural resource as the value of the asset depends on provisioning for future shocks and paying for protection
<b>Additionality</b>	Certifier establishes additionality but is subject to conflict of interest	Additionality increased thanks to the reduction in self-selection induced by the jurisdictional approach and the competition in the primary market.
<b>Leakage</b>	Rampant given the small size of projects	Large scale of jurisdiction reduces leakage
<b>Transaction costs</b>	Very high (certification, MRV)	Lower transaction costs thanks to larger size and reduced market fragmentation
<b>Risk-sharing</b>	Project developers bears all the risks	Investors bears the risks
<b>Valuation of non-carbon benefits</b>	Implicit, through the co-existence of several prices (per ton of CO <sub>2</sub> ) for different types of credits	Explicit, through the generation of a conversion rate for project attributes

#### 4.4 Remaining open design and governance issues

This chapter has so far laid out the contours of our proposed market design, but its implementation depends on several fine-tuning decisions that require a sound understanding of projects' specificities and their market and institutional context. We highlight a few here for illustration.

One question that arises is to what extent we should place strict conditions for project eligibility rather than let the market sort out projects according to their quality. Current attempts at fixing the voluntary carbon markets have taken the route of raising standards for eligibility. This increases the quality of the project pool but also reduces its size. In principle, our proposed market design allows for many project attributes and could accommodate a larger pool of projects. This is an advantage from a market scaling perspective as long as the list of project indicators can clearly distinguish between 'low-quality' and 'high-quality' projects. Too many indicators may generate obfuscation, rather than information.

A second question concerns the amount of provisioning. Depending on the project, the risk of impermanence may be so high that only limited carbon and biodiversity dividends can be distributed, reducing the project's investment value.<sup>13</sup> One alternative might be insurance. Several companies today offer carbon credits insurance to project developers. These insurance policies mainly cover the financial loss to project developers, however, and do not always include provisions to address the release of carbon due to the destruction of the forest or land. When they do, they provide funds for reforestation or purchase of carbon credits from other projects. One additional challenge in our context is that biodiversity is particularly place-specific and, therefore, even harder to compensate in case of a loss. As a result, insurance is only a partial substitute for provisioning in our context, and we only see a limited role for it.

A third question concerns the governance of funded projects. Shares in projects do not change the ownership of the land but, because shareholders bear the climate and biodiversity benefits risk, they should be able to influence or at least constrain the broad land management decisions. Appropriate governance needs to be put in place to respect land sovereignty and local environmental knowledge, which is highly place-specific and requires detailed expertise. One possibility is oversight by some international independent agency, which could check the implementation of the projects according to plans and, possibly, withhold some of the funds until full implementation. This approach would address investors' concerns about moral hazard, without changing ownership or land management rights by simply ensuring that jurisdictions indeed have the incentive to deliver according to their promises.

13 Note, however, that the large scale of our projects compared to most projects in the existing credit-based market already provides some risk diversification, reducing this risk.

A final consideration is the treatment of carbon dividends in the context of the Paris Agreement. Currently, some REDD+ credits are used by countries for their NDCs under Article 6.2. of the Paris Agreement – the climate benefit is transferred from the selling country to the buying country. This logic would apply here too: when project investors are countries, the benefit can be claimed for their NDC; when the investor is a private entity, the host country can keep the climate benefit.

#### 4.5 Ensuring demand

One aspect we have not discussed so far is the demand side. Today, the bulk of demand in the carbon and biodiversity markets stems from voluntary corporate action. This demand is bound to decrease as compliance markets expand.

Integration with compliance markets is not a desirable route. Even though some carbon credits are currently eligible for compliance and there are voices calling for further integration, Paris-aligned greenhouse gas emissions trajectories require both nature-based carbon sinks and anthropogenic emissions reduction. Counting nature-based carbon removals towards anthropogenic emissions reduction, as implied by market integration, would amount to double-counting (Cantillon and Slechten, 2024b). We need to reduce emissions and increase nature-based carbon removals. Integration is even more problematic in the case of biodiversity because biodiversity is highly place-specific.

This leaves regulation to ensure demand. One possible route is to mandate funds marketed in the European Union to offer Paris and Montreal-aligned portfolios. This goes beyond the Paris-alignment approach described in Bolton et al. (2022) in which decarbonisation is achieved through the choice of stocks in firms that are reducing their carbon emissions in line with the net zero transition pathways. Our scheme opens an additional possibility for decarbonising financial portfolios: shares in nature projects would be another class of (carbon-negative) assets that portfolio managers could use, in addition to equity and bond reshuffling, to reduce the carbon and biodiversity footprint of their portfolios. Pension funds, whose size can reach several times the national GDP in countries with deferred benefits systems, are another route. Given their long-time horizon perspective, some of these pension funds are already leaders in sustainable investment, but more could be done to nudge the vast amount of money these funds control. France, for example, has introduced an obligation for companies to offer so-called 90-10 savings funds to their employees, under which between 5% and 10% of the collected funds are invested in social enterprises and microfinance. The system is so popular that the ceiling has been raised to 15% in 2025.<sup>14</sup> This could provide a template for boosting demand for nature shares.

14 See <https://www.finance-fair.org/fr/actualites/epargne-salariale-vers-encore-plus-de-solidarite-grace-un-nouveau-decret> (accessed 2 March 2025).

## 5 THE CHALLENGE OF NATURE CONSERVATION

There is no doubt that nature conservation should be a priority. The damages from deforestation today are considerably larger than the climate and biodiversity gains from reforestation, afforestation, and nature restoration. Conserving existing forests is also in many cases cheaper than reforestation.

The challenge is the economics of conservation. Conservation avoids damages but generates lower flow benefits beyond those captured by local communities. Moreover, it is subject to recurring opportunity and maintenance costs.

The voluntary carbon market has somehow circumvented the problem by talking about emissions avoidance and creating credits based on what would have happened without funding. This trick has led to concerns about additionality and overcrediting, which no improvement in technology or governance can fix because conservation is intrinsically different from provision. Moreover, counterfactual scenarios based on projections of likely future land-use changes absent a nature conservation project will always remain highly uncertain given the challenge in predicting how increasingly unstable climate, and geopolitical conditions will affect a specific place and ecosystem

We formulate two desiderata for funding allocation mechanisms for nature conservation. The first desideratum is to guarantee additionality. Large areas of forests are currently not under threat and their conservation does not need to be financed. Additionality is important considering the funding gap for biodiversity. While COP16 signatories committed to mobilising \$200 billion annually for conservation by 2030, including \$20 billion in international contributions by 2025, current funding is much more limited. Existing mechanisms, such as the Global Biodiversity Framework Fund, have so far raised only \$383 million, highlighting the need for a more robust financial architecture.<sup>15</sup> The second desideratum is to encourage solutions that structurally reduce the threat to forests and other natural resources, thereby reducing the opportunity cost of conservation.

One option is to bundle conservation with provision and integrate both in the mechanism we have described in Section 4. This would have two advantages. First, by further expanding the geographical scope of projects offered for funding, it would not only further decrease leakage risk but also encourage reallocation of land where needed, contributing to the second desideratum. But it would reduce the climate and biodiversity returns of these projects, decreasing their attractiveness to investors and requiring public or philanthropic funding to close the gap.

15 To address this challenge, COP16 established a roadmap for biodiversity finance beyond 2030 and launched a high-level dialogue between environment and finance ministers to accelerate resource mobilisation. Although the agreement did not provide specific details on these mechanisms, it acknowledged the UN Biodiversity Finance Initiative (BIOFIN) catalogue, which outlines various financial solutions such as biodiversity offsetting and carbon credits (Carbon Pulse, 2025).

A second option is to develop a separate funding mechanism for conservation. The advantage is that this mechanism could be tailored in its governance to the specificities of conservation and, for example, prioritise areas for conservation depending on their natural value. This would contribute to meeting the first desideratum. The disadvantage of this option is the flip side of the advantages of the first option: it would generate no benefit in terms of leakage or efficient reallocation of land. We are agnostic as to the most appropriate option.

## 6 CONCLUDING COMMENTS

Nature provides immeasurable services to our societies, but it is in danger. External funding is needed, especially in the Global South, to support the provision and conservation of natural ecosystems. Markets can play a role to match projects and stakeholders interested in contributing, but the current market governance is plagued by poor incentives and low trust.

We have proposed a new market mechanism to channel funds to nature provision projects. The main innovation of our proposal is the move from the transactional credit-based approach of today to an approach where the main asset to be traded is a share in a project. We have argued that our approach would address many of the concerns about the existing market and, importantly, instil the needed long-term perspective in market participants. We propose that this new market design be coupled with a mandate or an incentive for funds (pension funds or any other market funds) to include shares in nature provision projects. This would ensure that there is sufficient demand for these shares. Moreover, leveraging financial funds, rather than companies, offers the additional advantage that the carbon and biodiversity benefits generated are not used to offset emissions or biodiversity damages by those that cause them directly. In our proposal, companies are still responsible for their emissions and biodiversity impacts.

In this chapter, we have focused on carbon and biodiversity dividends from forests for simplicity. However, nothing in the proposal limits the design's applicability to forests, or to these nature benefits. One could apply the same type of approach to peatland restoration, mangroves, and so on, as well as other ecosystem services such as water purification, pollination or nutrient cycling. The main constraint is practical: can we measure these benefits?

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## APPENDIX 1: NATURE AND BIODIVERSITY MEASUREMENT

In carbon markets, the universally accepted unit of account is a ton of CO<sub>2</sub> equivalent. In biodiversity and nature markets, no such standard exists. More than 600 different measures have been used, each capturing distinct aspects of habitat condition, species populations, and ecosystem health, as shown in an exhaustive review of metrics compiled by the Nature Positive Initiative in 2025.<sup>16</sup>

Effective biodiversity metrics must balance ecological detail with practicality. They should be transparent, straightforward to compute, and adaptable for organizations with varying capacities. Strong metrics incorporate biological diversity, habitat conditions, taxonomic-specific factors, and species of concern, drawing on local knowledge where relevant.

The challenge is not a lack of biodiversity metrics but their sheer variety and the absence of consensus on which to use. This inconsistency hinders the scaling of biodiversity markets. Table A1 provides an overview of key metrics currently in use.

<sup>16</sup> See <https://www.naturepositive.org/metrics/> (accessed 10 March 2025).

**TABLE A1 OVERVIEW OF THE MOST COMMONLY USED METRICS TO MEASURE NATURE AND BIODIVERSITY**

<b>Metric</b>	<b>Definition</b>	<b>Reference</b>
Biodiversity Habitat Index	Level of species diversity expected to be retained within any given spatial reporting unit as a function of the area, integrity and connectivity of natural ecosystems across that region	Harwood et al. (2022)
Biodiversity Intactness Index	Model-based indicator of terrestrial biodiversity which averages the abundance of a large and diverse set of organisms in a given geographical area, relative to their reference populations	Scholes and Biggs (2005)
IUCN Red List Index	Average of a score in {0, 0.2, ..., 1} that corresponds to an extinction stage of major species groups over time	Rowland et al. (2020)
Living Planet Index (LPI)	Geometric mean of the global abundances of all species in a defined taxonomic group, normalised to the baseline year (1970). Highlights average rates of change in a large number of populations of terrestrial, freshwater and marine vertebrate species	Loh et al. (2005)
Mean Species Abundance (MSA)	Average abundance of individual species under influence of a given pressure, compared to their abundance in an undisturbed situation	Schipper et al. (2020)
Potentially disappeared fraction (PDF)	Probability that a species, randomly chosen amongst all species present at a spot, will get extirpated	De Schryver et al. (2010)
Shannon Index	Diversity index that quantifies species richness, with higher values indicating greater diversity	Keylock (2005)
UK BNG: Biodiversity Unit	Standardised measure that calculates a habitat's ecological value by factoring in its size, condition, significance, type, difficulty of creation or enhancement, and the time required for restoration	DEFRA (2023)

## APPENDIX 2: ILLUSTRATIVE LIST OF PROJECT DESCRIPTORS

We propose that project descriptions cover at least the following aspects:

**Relevance and impact:** How will a significant reduction in GHG emissions and/or in the degradation of ecosystems/biodiversity be achieved directly from the project activities?

**Monitoring, reporting, and verification (MRV):** Based on which indicators will the reductions be verifiable and measurable in the short, medium and long term?

**Additionality:** Will the project have an additional impact compared to the 'business-as-usual' scenario and beyond any reduction already required under prior commitments of the country and/or affecting the place of the project, or by legal and judicial decisions in the country of the project?

**Permanence:** Will the project have a permanent effect? What measures will be adopted to ensure permanence?

**Do no harm:** What measures will be adopted to ensure that the project causes no significant negative impact on local communities and on other ecosystem services?

**Co-benefits:** Does the project generate environmental and/or social co-benefits? Which ones?

**Benefit sharing:** Will the local communities managing the ecosystems of the place of the project receive a fair share of financial resources?

**Risk management:** Which strategies are adopted to mitigate the risk of project failure and to compensate any actor that would be harmed by the project activities following unforeseen impacts?

**Leakage:** What measures will be adopted to ensure that the project will not cause a leakage/displacement of emissions or of activities associated with ecosystem/biodiversity degradation to another sector or another location?

**Systemic approach:** In what way does the project adopt a systemic approach to solutions and impacts?

**Financial feasibility:** Does the project have a high potential to be financially viable in the long term, intrinsically or through additional funding from public or private sources?

**Transparency:** What measures will be adopted to ensure that all relevant information on the project design, management and impacts will be disclosed in a transparent manner?



# Foreign transfers, biomass, and biodiversity in the Amazon

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*PUC-Rio and Climate Policy Initiative; Columbia University and CEPR*

## 1 INTRODUCTION

The current carbon budget for limiting global warming to 1.5°C is estimated to be less than 250 billion tons (Lamboll et al., 2023), while global emissions are estimated to be 37.4 billion tons of CO<sub>2</sub> per year (IEA, 2024). In this chapter, we argue that the world's tropical forests represent both a threat and an opportunity in the fight against the climate crisis. For example, deforestation of the remaining Amazon forest could produce emissions that surpass all historical emissions from the United States. On the other hand, natural reforestation of tropical forests could result in substantial carbon capture. The 50+ million hectares of deforested area in the Brazilian Amazon have the potential to capture almost 23 Gt of CO<sub>2</sub>, the vast majority in the next 30 years. Considering the vast amount of deforested areas in other tropical forests, it becomes evident that reforestation presents a significant opportunity for carbon capture, especially while the world awaits technological advances to address the climate crisis.

Advancing the integration of forest management into the climate agenda, while leveraging the opportunities presented by climate policies to safeguard tropical forests, requires an integrated and coordinated approach. Addressing issues such as leakages and spillovers demands a jurisdictional strategy, which moves beyond project-level initiatives to account for the ecological interconnectedness of tropical forests.

It is also important to differentiate between three closely related but distinct challenges. First, forest restoration – especially through natural regeneration – offers vast potential for carbon capture at scale and at a lower cost. However, the absence of scalable financial and policy mechanisms currently limits the realisation of this potential. Second, while global agricultural land use has decreased by 2% since 2001 with productivity rising by 60% (FAO, 2024), deforestation remains a critical problem in tropical regions. High rates of forest loss push many areas closer to ecological tipping points, jeopardising their long-term integrity (e.g., Flores et al., 2024). Lastly, conserving forests with high

<sup>1</sup> We thank Beatrice Weder di Mauro for thoughtful comments, and Patricio Hernandez and Preach Apintanapong for very able research assistance.

ecological integrity but low deforestation pressure is essential. While these areas may not face immediate threats, historical patterns show that infrastructure expansion and settlements can lead to significant deforestation, often clearing land that proves unsuitable for agriculture and is later abandoned.

This chapter takes an integrated approach to these challenges. Drawing on Assunção et al. (2023b), we demonstrate how carbon pricing mechanisms can simultaneously reduce deforestation and accelerate large-scale forest restoration. Additionally, the recently proposed Tropical Forest Forever Facility (TFFF) is examined as a complementary tool for incentivising the protection of forests with high ecological integrity. Recognising the diversity of challenges faced by different countries and regions, we focus on the Amazon rainforest – the world’s largest tropical forest – which provides a unique case study for exploring these solutions.

From the perspective of long-term tropical forest protection, we highlight carbon capture as a vital ecosystem service that presents an opportunity to mobilise financial resources for forest protection and restoration over the next critical decades for addressing climate change. We also emphasise biodiversity as a fundamental component of tropical forest ecosystems. Beyond its intrinsic value, biodiversity provides critical ecological benefits and reinforces the resilience of forests. In this chapter, we highlight the need for targeted policies and mechanisms to conserve biodiversity and prevent forests from reaching ecological tipping points. By integrating these considerations, we underscore the importance of a more integrated approach to forest conservation, ensuring both immediate and long-term ecological and climate benefits.

The remainder of the chapter is structured as follows. Section 2 examines the ecological and economic importance of the Amazon, highlighting its role in carbon storage, biodiversity, and the water cycle. Section 3 discusses the need to address heterogeneity among Amazon countries, considering differences in conservation and forest restoration opportunities. Section 4 explores performance-based carbon payments as a mechanism to incentivise large-scale forest restoration, assessing its economic feasibility and climate benefits, while also introducing the Tropical Forest Forever Facility as a complementary results-based approach for protecting standing forests. Section 5 analyses key implementation challenges, including incentive structures, financing strategies, and comparisons with alternative carbon capture and storage (CCS) technologies. Finally, Section 6 assesses the potential integration of Amazonian carbon capture into international carbon markets and its implications for food production. The report concludes by summarising key findings and reinforcing the importance of integrating forest conservation into global climate policies.

## 2 WHY SHOULD WE SAFEGUARD AND RESTORE THE AMAZON?

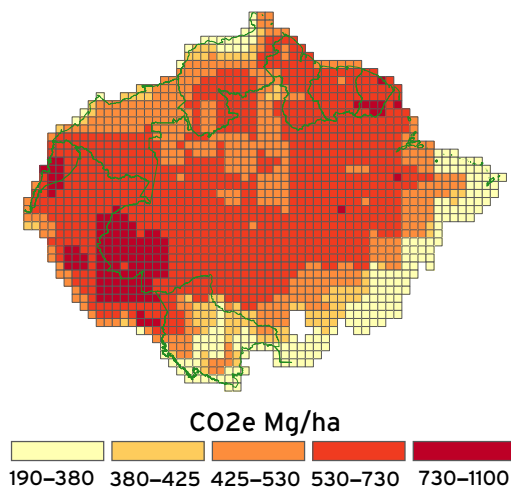
The Amazon forest, the largest tropical forest in the world, is approaching a tipping point, as increasing deforestation, fires, droughts, and rising temperatures compromise its ecological stability. Historically resilient, the forest is now subject to disruptive feedback mechanisms that could lead to widespread degradation. By 2050, up to 47% of the Amazon could experience compounding environmental stressors, amplifying regional and global climate change (Flores et al., 2024). Addressing this trajectory requires immediate and coordinated efforts to curb deforestation and implement large-scale restoration.

The ongoing degradation of the Amazon places its carbon stocks, biodiversity, and ecosystem services under significant threat. While their relative importance varies across the region, available data underscore their critical role throughout the biome. Moreover, the full extent of their ecological and economic value remains incompletely understood, further reinforcing the urgency of conservation efforts. Establishing this context is essential before evaluating potential mechanisms for forest conservation and restoration.

### 2.1 Carbon

Figure 1 represents the variation of the maximum potential biomass per hectare, measured in CO<sub>2</sub> equivalent, across the Amazon forest. Each colour denotes a quintile of the distribution.

FIGURE 1 MAXIMUM POTENTIAL BIOMASS PER HECTARE



Notes: Estimates produced using above ground biomass density data for 2017 (<https://climate.esa.int/en/projects/biomass>) along with the procedure described in Assunção et al. (2023b).

Column 3 of Table 1 uses the data behind Figure 1 and Souza et al. (2020) to display the maximum amount of CO<sub>2</sub> that each Amazonian country could eventually accumulate from fully reforesting the biome. For instance, in the case of Brazil, the 50 million hectares of deforested land<sup>2</sup> could capture 23 Gt of CO<sub>2</sub>. This amount is substantially smaller in other countries, because deforested areas are much smaller.<sup>3</sup> If Brazil was paid \$25 per net ton of captured carbon, and reforestation was instantaneous, the value of these transfers would amount to \$572 billion. This amount does not account for the dynamics of tree-growth, time discounting, the loss of income from the current agricultural activity, or costs of changing land-use. On the other hand, it also does not account for the value of forest services other than CO<sub>2</sub> capture, including economic activity compatible with preservation such as production of nuts, cocoa, açai or natural rubber. In Section 4.1 we discuss results from Assunção et al. (2023b), which account for these adjustments.

TABLE 1 POTENTIAL CO<sub>2</sub> CAPTURE ACROSS AMAZON COUNTRIES

Country	Standing forest area (million hectares)	Deforested area (million hectares)	Maximum carbon capture (CO <sub>2</sub> e Gt)
Bolivia	20.15	1.73	0.78
Brazil	314.49	50.14	22.89
Colombia	36.73	2.39	1.12
Ecuador	6.86	0.02	0.01
Guyenne (France)	7.34	0	0
Guyana	15.49	0.01	0.01
Peru	55.25	0.28	0.17
Suriname	11.36	0	0
Venezuela	35.95	0.9	0.35

## 2.2 Biodiversity

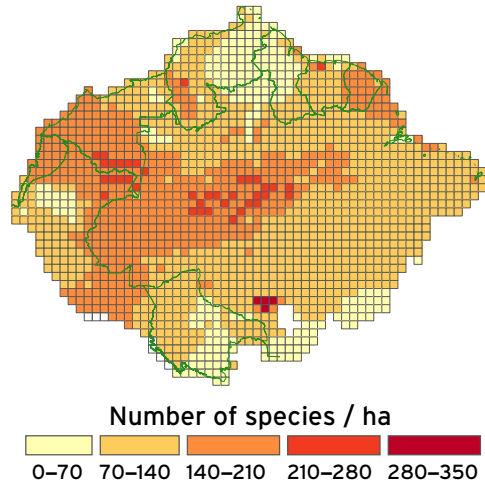
The Amazon forest is home to over 15,000 tree species, most of which are rare. Figure 2 uses data from Ter Steege et al. (2023) and our calculations to show the distribution of potential species-count biodiversity in the biome across plots of 67km × 67km. Plots with the highest potential biodiversity are in portions of Western Amazon and Guyenne (France); those with the lowest potential in portions of Guyana, Southern Amazon, and in the upper Rio Negro.

2 This excludes urban areas, lakes, and rivers.

3 Variations in carbon capture capacity also matter, but are less material.

Protecting biodiversity of trees in tropical forests goes hand in hand with protecting the land itself. Therefore, avoiding deforestation is crucial for maintaining biodiversity. Moreover, evidence suggests that naturally reforested sites in tropical forests can regain 90% of the original species count relatively quickly (Rozendaal et al., 2019). Thus, in addition to capturing CO<sub>2</sub>, natural reforestation would produce restoration of biodiversity.<sup>4</sup> Enhancing biodiversity and carbon capture can be complementary objectives.

FIGURE 2 POTENTIAL NUMBER OF SPECIES PER HECTARE IN THE AMAZON



Source: Ter Steege et al. (2023)

One important difference is that while the social cost of carbon is used to value the impact of emissions, there are no commonly accepted criteria to evaluate biodiversity changes.<sup>5</sup>

A relatively small portion of the value of biodiversity would come from measuring the impact of biodiversity loss on the remaining biomass, as documented in O'Connor et al. (2017). Hansen and Scheinkman (2024) estimate that deforestation in 1985-2017 caused an average biomass loss of 12.6% and a loss of 4% of biodiversity to the average plot in Figure 2. In turn, this biodiversity loss caused additional biomass losses in preserved areas, which resulted in 0.8 Gt of additional emissions, the equivalent of 15% of annual US emissions.

<sup>4</sup> In contrast, capturing carbon using species foreign to the biome or just a few natural species would damage biodiversity.

<sup>5</sup> In addition, species-count is only one of the many possible measures of biodiversity.

## 2.3 Water cycle

Forests play a crucial role not only in carbon storage and biodiversity, but also in regulating the water cycle. Through evapotranspiration, vegetation recycles rainfall by converting soil water into atmospheric moisture, influencing the transport of humidity across regions (Salati et al., 1979; Aragão, 2012; Beveridge et al., 2024). This creates an additional layer of externality, where disturbances in one forest area can trigger cascading effects on other forest regions and beyond.

This mechanism directly affects the integrity of the forest itself. Deforestation in the eastern Amazon, for example, can reduce the ability of the downwind forests to sustain their biomass, increasing the risk of crossing a tipping point where deforestation beyond a certain threshold could cause irreversible damage to the ecosystem (Lovejoy and Nobre, 2018). Araujo et al. (2023) show that forest degradation can, on average, double its impact on other areas due to this process. In some regions, the Amazon already emits more carbon than it absorbs, signalling that this destabilisation is underway (Gatti et al., 2021). Furthermore, estimates indicate that a substantial fraction of the Amazon is highly exposed to this risk in the coming decades (Flores et al., 2024).

However, disruptions in the water cycle and the rainfall regime extend far beyond the forest itself, generating significant economic impacts in downwind areas outside the biome. This is particularly concerning for agriculture, as deforestation has been shown to reduce precipitation and affect crop yields (Leite-Filho et al., 2021; Spracklen et al., 2012; Araujo, 2023). In addition, hydropower energy generation, which relies on stable water flows, is also vulnerable to deforestation-driven changes in the water cycle (Stickler et al., 2013; Araujo, 2024).

## 3 THE CHALLENGE OF CONSERVATION AND RESTORATION ACROSS AMAZON COUNTRIES

Each Amazon country operates within a distinct ecological and economic context regarding forest conservation and restoration opportunities. The substantial variation in forest cover, deforested areas, and carbon sequestration potential underscores the need for designing targeted incentives that both enhance forest restoration efforts and safeguard standing forests. As shown in Table 1, countries such as Guyenne (France), Guyana, and Suriname exhibit minimal deforestation, limiting their potential benefits from transfers for net carbon capture resulting for forest restoration. Conversely, Brazil's extensive deforested areas present a significant opportunity for carbon sequestration, highlighting the need for policies that induce restoration benefits.

Thus, effectively promoting forest restoration while preserving remaining forest areas requires a portfolio approach that would allow each country to adopt a composition of mechanisms better tailored to its specific ecological and economic context.

## 4 TWO POSSIBLE MECHANISMS FOR FOREST CONSERVATION AND RESTORATION

Conservation efforts are largely driven by public policies that include payments for environmental services, protected areas, and other regulatory measures. However, these policies are often implemented in countries with limited state capacity, financial constraints, and unclear land tenure systems (Balboni et al., 2023). Given the global externalities associated with tropical forests and the challenges of existing policies in effectively ensuring conservation and restoration, there is a growing need to design external incentives for governments.

This section examines how international carbon payments can offer a unique opportunity to reduce deforestation and promote forest restoration. It also analyses a recent proposal by the Brazilian government that serves as a complementary strategy to reward areas with high forest integrity and low deforestation, thereby reinforcing large-scale conservation efforts. Together, these two mechanisms form a flexible portfolio capable of addressing the diverse challenges faced by tropical forests, by creating targeted incentives for restoration, reduced deforestation, and forest conservation across different national contexts.

### 4.1 Performance-based carbon payments for forest restoration

In Assunção et al. (2023b), we examine the implications of performance-based carbon payments for forest restoration in the Brazilian Amazon. The study focuses on a jurisdictional approach, in which annual payments are allocated based on the net carbon balance, accounting for carbon sequestration through forest regrowth minus carbon emissions from deforestation and cattle ranching activities. These payments can be generated through a variety of mechanisms, ranging from offset credits within cap-and-trade markets to more innovative approaches, such as the one proposed by Cantillon, Lambin, and Weder di Mauro in their contribution to this volume.

Under this mechanism, the optimal balance between deforestation and reforestation is determined by the relative productivity of alternative land uses and the economic valuation of forest conservation. To assess the potential social benefits of conservation and reforestation, we employ a dynamic spatial optimisation model that quantifies the trade-offs between cattle ranching – the predominant land use in deforested areas of the Brazilian Amazon<sup>6</sup> – and carbon sequestration. The model is quantitative, incorporating high-resolution spatial data from multiple sources to generate a detailed assessment of the policy's impacts.

6 Approximately 85% of deforested land still in use is dedicated to cattle ranching.

The data document large cross-sectional variability in cattle farming productivity and in the potential absorption of carbon. To account for this variability, the model considers a partition of the Amazon into 1000+ sites.<sup>7</sup> If paid \$25 per net ton of carbon captured, Brazil would choose to reforest most of the previously deforested biome. The low implicit price for carbon is a consequence of the low productivity of cattle production in Amazon. Note that there is no payment for simply conserving, since payment is based on net capture. This is because, at \$25 per net ton, Brazil would face an average opportunity cost of approximately \$12,500 per hectare deforested, this opportunity cost exceeding \$8,500 in 80% of the land – an amount that could not be compensated by future cattle farming profits. On net, we calculate that Brazil would receive \$422 billion in present value of transfers in the next 30 years, amply compensating the value of the cattle production lost and land-use changes. After accounting for the value of other forest services, we estimate Brazil would gain \$282 billion in present value over 30 years, relative to the case in which no transfers are paid.

Perhaps more importantly, we estimate that the Brazilian Amazon would capture 18 GtCO<sub>2</sub> over 30 years, instead of emitting 16 GtCO<sub>2</sub> in 30 years in the business-as-usual trajectory. Thus, the emissions variation from current business-as-usual to \$25/ton amounts to 34 GtCO<sub>2</sub> in 30 years. This is a substantial amount especially compared with current 1.5°C budget ~ 250 GtCO<sub>2</sub>. Since Brazil is only paid for the 18 GtCO<sub>2</sub> of net capture, the effective cost per ton is only \$13.25/ton. This compares extremely favourably with the cost of carbon capture and storage schemes currently encouraged by advanced countries, which we discuss in Section 5.5 below.

We do not have data that allow us to calculate the present value of gains in the first 30 years for other biome countries. However, assuming this present value is the same proportion of the maximum value for all countries, we produce estimates of net gains in column 1 of Table 2. Note that gains for Brazil from reforestation is more than 20 times that of Colombia, which has the second-largest gain. This again reflects the much larger deforested area in Brazil than in any other biome-country.

#### 4.2 Tropical Forests Forever Facility (TFFF)

Brazil launched a new results-based initiative to reward tropical forests at COP28 in Dubai.<sup>8</sup> Unlike other approaches, this mechanism introduces payments for protecting standing forests, focusing on the intrinsic value of forests rather than specific ecosystem services, such as carbon storage. This mechanism complements previous efforts to leverage carbon pricing to promote forest restoration and prevent deforestation by providing compensation for standing forests with low deforestation risks.

7 In Assunção et al. (2023b) we also account for ‘deep uncertainty’ resulting from imprecise knowledge of crucial productivity parameters.

8 The TFFF framework is still being developed. In this section, we consider the structure outlined in Federal Government of Brazil (2025).

**TABLE 2 NET GAINS OVER THE FIRST 30 YEARS FROM CARBON CAPTURE VERSUS TFFF (\$ BILLION)**

Country	Net gains from performance-based carbon payments (\$ billion)	TFFF (\$ billion)
Bolivia	9.66	1.84
Brazil	282.22	28.74
Colombia	13.79	3.36
Ecuador	0.18	0.63
Guyenne (France)	0.01	0.67
Guyana	0.08	1.42
Peru	2.11	5.05
Suriname	0	1.04
Venezuela	4.32	3.29

Note: TFFF computation assumes zero deforestation in each country, no conservation costs, and \$4 per year for each hectare of forest.

The proposal sets eligibility criteria requiring tropical forest countries to maintain deforestation rates below 0.5% per year. Countries with yearly deforestation rates above this threshold are not allowed to participate. Once in the mechanism, countries would receive

\$4 per year for each hectare of standing forest. These allocations would be reduced by the equivalent of 100 hectares for every hectare deforested or degraded. Any forgone allocations would remain within TFFF, benefiting sponsors and creating a fund to reward nations that achieve net forest cover increases through reforestation. Verification would rely on an established satellite monitoring system to ensure simplicity and reliability.

The deforestation penalty is crucial as it incentivises reduced deforestation, avoiding substantial emissions. While this penalty alone may not suffice to halt deforestation, it ensures consistency with the overarching goal of rewarding conservation.

There is a natural reluctance to pay for carbon emission avoidance. After all, it seems unreasonable, and certainly unaffordable, to pay Europe or the United States for coal kept underground or to pay Canada for not using all tar-sand deposits. However, as Figure 4 shows, the per-capita responsibility of individual countries for carbon accumulation in the atmosphere, perhaps not surprisingly, aligns extremely well with current income per capita. Hence it makes sense to use a programme such as TFFF to help some poorer countries to confront the energy transition while benefiting from the conservation of tropical forests.

Another eligibility consideration is donor concerns over, for example, nations that lack democratic governance or that do not uphold civil rights. To address this, TFFF could allow contributors to create tailored beneficiary lists from among the eligible nations. This flexibility might expand the contributor base while avoiding more distortionary measures to address these issues.

### 4.3 Simulating performance-based carbon payments and TFFF for Amazon countries

To illustrate how heterogeneity among Amazon countries influences the relative importance of carbon payments and TFFF, we simulate potential revenues under each mechanism. The simulation assumes zero deforestation and full restoration of all previously deforested areas, allowing us to highlight how different countries would benefit. Nations with higher historical deforestation would benefit more from carbon payments, while those with minimal deforestation would find TFFF to be their main revenue source.

Table 2 presents the results under this scenario. Ecuador, Guyana, Guyenne (France), Peru, and Suriname would prefer TFFF over a carbon capture scheme priced at \$25 per ton. In contrast, Bolivia, Brazil, Colombia, and Venezuela would benefit more if carbon capture were rewarded at \$25 per net ton of CO<sub>2</sub> captured or higher. Additionally, if TFFF includes a maximum income threshold, French Guiana (France) may be ineligible.<sup>9</sup>

## 5 IMPLEMENTATION

### 5.1 Jurisdiction approach

In principle, forest conservation and restoration can be implemented at the project level. Nonetheless, there are good ecological and economic reasons why forest restoration should be implemented at the level of the largest feasible jurisdiction.

Among the ecological reasons for large-scale projects is sensitivity to fires. Due to intense humidity, tropical rainforests – in contrast to temperate forests – are not subject to large natural fires. In the Amazon, however, fires started to renew pasture often spread and cause forest degradation.<sup>10</sup> Large forest fires can occur in these degraded forests. A larger contiguous protected area would have proportionally much less contact with unregulated areas at the border and thus be substantially more immune to accidental fires. In addition, forest fragments (i.e., areas of less than 100 square kilometres) display deteriorated carbon accumulation dynamics (e.g., Cochrane and Laurance, 2002).

<sup>9</sup> These comparisons consider revenues from each programme separately. Potential interactions between programmes, although feasible, are not accounted for in this simulation and could alter the results.

<sup>10</sup> "In the extensive beef-cattle production, annual or biennial fires are commonly applied to stimulate grass regrowth in the dry season when forage is in short supply. Most cattle ranchers do not make firebreaks and the fire spreads to large areas" (Pivello, 2011).

There are economies of scale in forest protection efforts, as demonstrated by the Brazilian Amazon experience, where much of the deforestation is driven by illegal land appropriation. Effective law enforcement is crucial to deterring land grabbers from clearing areas designated for forest restoration. Brazil's success in curbing illegal deforestation highlights the role of satellite-based monitoring systems, particularly DETER, launched in the early 2000s. DETER provides near real-time deforestation alerts, significantly enhancing state capacity and law enforcement by enabling rapid intervention.<sup>11</sup> Assunção et al. (2023a) show that DETER-driven enforcement efforts had a major impact, preventing over 10 GtCO<sub>2</sub> of emissions at a cost of less than \$1 per ton of CO<sub>2</sub>. Actual deforestation rates in the Brazilian Amazon fell by more than 80% between 2004 and 2012. This cost-effectiveness is largely due to the economies of scale associated with satellite-based surveillance systems, demonstrating that large-scale monitoring can be a powerful tool for forest conservation. Unfortunately, as discussed in Burgess et al. (2019), starting in 2012 the Brazilian government severely restricted enforcement, resulting in a return to higher deforestation rates.

## 5.2 Financing TFFF

The original proposal of TFFF involves creating a fund through sovereign investments, which could take the form of long-term deposits at low interest rates or guarantees enabling the issuance of low-cost bonds. The fund would allocate resources to a diversified portfolio (fixed income and equity) to generate higher returns as a spread. TFFF would then benefit from the net performance of these investments (minus administrative costs) in the form of an investment fee. There is also a suggestion to establish a tranche of \$25 billion to cover first losses and subsequently issue an additional \$100 billion at commercial rates as a possible implementation route.

Under this framework, the total resources available depend on investor willingness to accept lower returns or higher risks. According to modern financial literature, it is unlikely that the TFFF will generate substantially more than the foregone returns of low-interest contributors or the premium for the expected losses from risk-bearing participants. This mechanism is therefore particularly attractive to actors unable to directly support forest conservation through grants or direct payments, such as sovereign bond issuers.

However, the proposed structure allowing for risky investments poses volatility risk. Unless the vast majority of deposits come from below-market-rate contributions, fluctuations in returns of risky investments would lead to fluctuations in available resources, potentially undermining the mechanism's incentive structure.

11 These data have been instrumental in seizing and destroying heavy machinery used for deforestation.

There is no reason to focus exclusively on the proposed fund as a source for TFFF. Formulating TFFF as a broader facility, emphasising the last 'F', could open the door to contributions from private sector companies, individuals, non-profit funds, and governments. While this option is hinted at in the proposal, it has been downplayed during discussions. Given uncertainties regarding the reliability of each funding source, keeping this possibility open at this stage would be prudent.

Ultimately, the resources distributed to forest nations at the end of each year would consist of the sum of direct contributions plus the investment fee from the fund.

### **5.3 Long-term viability of forest restoration carbon credits**

The permanence of carbon credits is a common challenge in forest restoration projects. As restored forests mature, their rate of carbon sequestration declines, eventually limiting the generation of new credits. This creates a time-consistency problem, where economic incentives may no longer be sufficient to prevent future deforestation once credit revenues decrease. Ensuring long-term forest protection requires mechanisms that maintain commitment, either through penalties or rewards. One possible approach is a 'carrot' mechanism, where sellers receive a balloon payment if the restoration project is successfully maintained for a designated period, such as 50 years. Calculations reported in Scheinkman (2024) for the case of Brazil show that, if transfers are set at \$25/ton, the added cost to buyers would amount to less than 55 cents per ton of CO<sub>2</sub> captured. Alternatively, one could design 'sticks', which might include banning imports originating from the biome.

In the reverse direction, Brazil would need guarantees that once cattle-farming is abandoned and land is dedicated to restoration, payments for future carbon-capture will effectively occur. This second time-consistency requirement and the monetary scale of the scheme, involving payments that exceed \$17 billion in some years, require that buyers be countries, or group of countries, with excellent credit ratings, perhaps intermediated by international organisations such as the World Bank.

### **5.4 Use of proceeds and the role of the private sector**

Since both carbon payments and TFFF are results-based mechanisms, where payments are tied to forest conservation and restoration outcomes, funds should be allocated directly to national governments without strict restrictions. Imposing conditions on these funds would interfere with the domestic political processes of the recipient countries. Because mechanisms reward national-level outcomes, governments should have the autonomy to allocate resources in ways that best serve forest protection, restoration, and local populations.

Both mechanisms create incentives for forest conservation and restoration through a broad range of activities, including the establishment of protected areas and indigenous territories, environmental regulations, and law enforcement. However, while governments are ultimately responsible for large-scale carbon capture and payments, the private sector also has a crucial role to play. Data on abandoned deforested areas undergoing natural reforestation (for at least six years) indicate that CO<sub>2</sub> capture in these areas often exceeds model predictions. Nonetheless, in some cases, active forest restoration may be more economically efficient than relying on natural regeneration alone (Assunção et al., 2023b). Given this, private sector involvement could be particularly beneficial in active restoration efforts, especially in highly degraded areas. The price differential between the \$25 per ton of CO<sub>2</sub> capture rate and higher carbon prices in international markets (such as in the EU ETS) creates ample room for private investment in boosting carbon sequestration through more intensive restoration strategies.

Beyond direct forest restoration, the private sector can also contribute through sustainable forest-based products. Activities such as açai, tropical fruit, fish, and nuts, along with agroforestry products like cacao and black pepper, already engage local communities and are compatible with native forest management. Expanding these forest-compatible industries can enhance economic opportunities while reinforcing conservation efforts.

### 5.5 Reforestation versus other carbon capture and storage schemes

Carbon capture and sequestration (CCS) schemes in the United States, as well as other countries, involve predominantly capture for use to enhance the yield from old oil/gas reserves ('enhanced oil recovery', or EOR). The United States is the largest deployer of CCS projects. The Congressional Budget Office reported in September 2023, however, that the 15 CCS facilities then operating in the country had the capacity to capture only 0.4% of the nation's total annual CO<sub>2</sub> emissions. Ninety-five percent of the capacity provided by these 15 facilities was used for enhanced oil recovery. An additional 121 CCS facilities were under construction or in development at the time. If these facilities are completed, US carbon capture and sequestration annual capacity would amount to 165 million tons, or 3% of current annual CO<sub>2</sub> emissions.

Once we consider the extra CO<sub>2</sub> emitted by the additional production of carbon-based fuel, it is not clear how much net capture of CO<sub>2</sub> each of these facilities yields, but Occidental Petroleum, currently developing large carbon removal facilities projects in Texas, uses CCS to sell "*net-zero oil* [sic]". It is not by accident but by design that CCS projects increase fossil fuel production. A joint report on the 2010 symposium on the role of enhanced oil recovery in accelerating the deployment of carbon capture and Sequestration, co-hosted by the MIT Energy Initiative (MITEI) and the Bureau of Economic Geology at the University of Texas (UT-BEG) states: "*The motivation [for CCS] ... lies with the convergence of two national energy priorities: enhancement of*

*domestic oil production through increased tertiary recovery; establishment of large-scale CCS as an enabler for continued coal use in a future carbon-constrained world. These security and environmental goals can both be advanced by utilizing the carbon dioxide (CO<sub>2</sub>) captured from coal (and natural gas) combustion for EOR” (MIT Initiative, 2010).*

Under the Inflation Reduction Act (IRA), CCS projects that utilise captured CO<sub>2</sub> for EOR are eligible for a tax credit of \$60 per ton, provided construction begins before 2033 and prevailing wage requirements are met during the first 12 years of operation. The values are substantially higher for other CCS pathways: \$85 per ton for CO<sub>2</sub> that is permanently stored (without EOR), and significantly more for direct air capture (DAC) projects (\$180 per ton for CO<sub>2</sub> permanently stored and \$130 per ton for CO<sub>2</sub> used in applications like EOR).

CCS projects have long-term risks that private companies cannot or are not willing to hold. In fact, limited liability implies that indemnification for loss is only possible up to the value of the firm’s assets (Gollier, 2005). This explains why long-term liability for leaks in CCS are often transferred to governments ex ante, even for projects undertaken by well-funded firms.<sup>12</sup>

## 6 ADDITIONAL CONSIDERATIONS

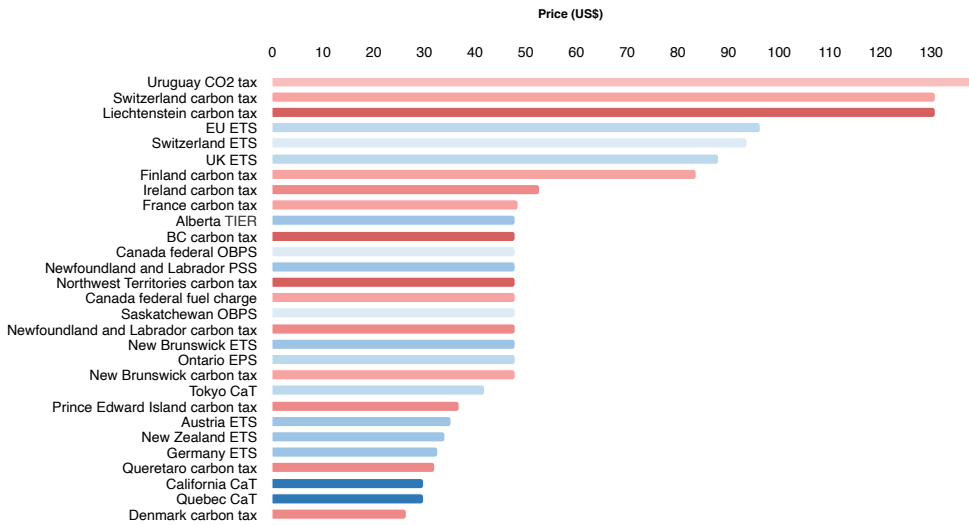
### 6.1 Emissions price-dispersion

Figure 3 shows April 2023 prices reported by the World Bank for direct carbon pricing instruments and carbon markets around the world that exceed of at least \$25 (the amount we estimate would produce notable carbon capture via reforestation in the Brazilian Amazon). Notice that some of the largest programmes, such as the EU ETS, display prices that are multiples of \$25.

Since an additional ton of CO<sub>2</sub> has the same impact on global climate change wherever it is emitted or captured, basic economic principles suggest that efficiency requires uniform carbon pricing, regardless of location. This is the fundamental rationale behind tradable emissions schemes like the EU ETS, where all participating countries are exposed to a single carbon price.

12 For instance, the Australian Commonwealth and Western Australia state agreed to take over liability of Gorgon CCS project from Chevron and partners that include Shell and Exxon-Mobil after closing of project.

FIGURE 3 CARBON PRICE ACROSS COUNTRIES IN 2023



Note: Prices of April 2023.

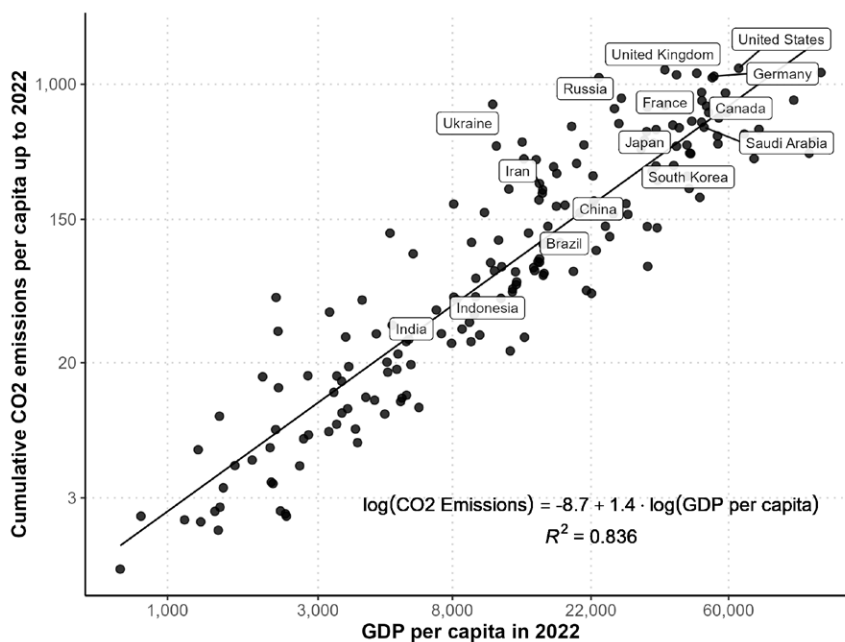
Source: World Bank carbon pricing dashboard.

However, countries have contributed very differently to historical carbon emissions and the exhaustion of the global carbon budget. Since the Industrial Revolution, economic development has been closely tied to greenhouse gases emissions, as illustrated in Figure 4. Recognising this disparity, the United Nations Framework Convention on Climate Change (UNFCCC) established the principle of Common But Differentiated Responsibilities (CBDR), acknowledging that countries bear differing levels of responsibility for climate change. However, this is better dealt with by giving less developed nations a free and sellable quota of emissions and having these countries face the same emissions price for additional emissions. Currently, European firms may use imported inputs, such as US liquified natural gas (LNG) or Chinese PV panels to satisfy EU requirements, but are not allowed to obtain credit for paying for carbon capture abroad.<sup>13</sup> Common objections to purchase of non-EU carbon capture credit include the argument that CCS is an infant industry that needs protection. In general, if governments want to help develop local CCS or other technologies that, though inefficient today, show promise for the future, they should give additional subsidies to developers of these technologies, but there is no obvious reason why the subsidy should be proportional to current output as tariffs or prohibition of imports are. Another objection is that accepting non-EU carbon capture credit would export CO<sub>2</sub> emissions. In the case of net-payment schemes such as the one discussed here, this is not a concern. Brazil would face a loss for \$12,500 per hectare

13 The European Carbon Adjustment Mechanism (CBAM) focuses on specific goods, and imported PV panels or natural gas are not currently covered and thus exempt from EU carbon pricing. In addition, the carbon footprint of production and transportation of natural gas is substantially underestimated (Alvarez et al., 2018).

deforested.<sup>14</sup> Currently, Amazon deforestation is responsible for close to 50% of Brazil's emissions and, at \$25/ton, the country would reduce almost immediately its own emissions by 40–50%, which exceeds the EU goal of reducing its own emissions by 30%. In addition, carbon capture in reforested areas would further reduce net emissions over a relatively short time horizon.

FIGURE 4 GDP PER CAPITA AND CUMULATIVE CO<sub>2</sub> EMISSIONS PER CAPITA



Data source: Our World in Data.

Of course, in the case of carbon capture, the subsidy must also reflect the resilience of the capture. As we argued above, a properly designed scheme for carbon capture in tropical forests can be made very resilient. In addition, establishing compensation for carbon capture requires establishing an accounting system that credits only once any carbon capture.

The politics of climate action has led to programmes with widely varying carbon prices. In this context, countries should permit firms to meet part of their emissions targets by purchasing carbon credits from the Amazon. This approach would increase funding for the region, help reduce carbon price disparities, and enhance the overall efficiency of global climate mitigation efforts.

14 This does not apply for the isolated reforestation projects paid by NGOs or private companies now prevalent. There is no guarantee that inputs used for deforestation would not simply move elsewhere.

## 6.2 Effect of reforestation in the Amazon on other regions

The beef industry in the Brazilian Amazon is very inefficient, but survives thanks to a mix of tolerance for informality (85% of workers are informal), credit subsidies provided to the Brazilian cattle industry, land grabbing, and speculation of capital gains that would result from state action, such as paving a nearby road or granting of an amnesty awarding property rights to illegal land that is used for a sufficient time for cattle grazing, as the amnesty provided in 2012. Nonetheless, the biome beef industry accounts for 23% of Brazilian and 3% of the world's meat production. Using the average price elasticity of beef reported in the meta-analysis of Andreyeva et al. (2010) of 0.75, we conclude that beef prices would increase by less than 4% if the full biome is restored and supply outside the biome stays the same. It is notoriously difficult to estimate supply responses for beef because of the dynamics of beef production. Nonetheless, the amount of annual beef output per hectare in non-Amazonian Brazil is markedly higher than in the Amazon, which should lower the effect of any resulting price increase on deforestation in other areas. In addition, the effect of reforestation of the biome on the water cycle (see Section 2.3) would improve crop yields and consequently food supply in downwind regions.

## 7 CONCLUSION

The Amazon rainforest plays a crucial role in global climate stability, biodiversity conservation, and water cycle regulation. Its protection and restoration provide a cost-effective and scalable solution for carbon sequestration, making it a key element of international climate mitigation efforts. However, each country within the Amazon region faces unique economic and ecological conditions, meaning the benefits of conservation and forest restoration vary across contexts.

This chapter underscores the economic and environmental importance of the Amazon, demonstrating how results-based mechanisms – such as performance-based carbon payments and the Tropical Forest Forever Facility (TFFF) – can drive conservation while delivering significant economic benefits to Amazonian nations. These two mechanisms offer a complementary and flexible framework for forest management, aligning incentives with the specific challenges and opportunities of each Amazon country.

Our analysis highlights that forest restoration through natural regeneration in the Amazon could capture up to 18 GtCO<sub>2</sub> over the next 30 years at a significantly lower cost than alternative carbon capture and storage (CCS) technologies, based on simulations from the Brazilian Amazon. The proposed carbon payment framework aligns economic incentives with conservation objectives, making forest protection not only an environmental necessity but also an economically viable strategy. Additionally, TFFF serves as a complementary mechanism, providing long-term financial incentives for countries with low deforestation rates to sustain and protect their standing forests.

The political economy of climate finance remains a key challenge. Significant disparities in carbon pricing across countries hinder the efficiency of global mitigation efforts. Given the urgent need to close the emissions gap while ensuring equity, integrating Amazonian carbon capture into international carbon markets would help reduce price disparities while increasing the financial resources available for conservation. The private sector also has a crucial role to play, particularly in fostering sustainable, forest-compatible economic activities and investing in active restoration in degraded areas.

Ultimately, the protection and restoration of the Amazon represent a unique opportunity to align climate action with economic development. By implementing performance-based mechanisms and ensuring long-term financial sustainability, the global community can secure the future of the world's largest tropical forest while addressing climate change. Tropical forests from other countries beyond the Amazon can also benefit from transfer payments for reforestation and conservation. In return, we would obtain more breathing time to wait for the technological solutions that could help us reach net zero.

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# Governing the green transition: Planning, markets, and financial governance in China and India

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## 1 INTRODUCTION

The climate change crisis will be won or lost in China, India, and other emerging market economies. China is currently the largest emitter, but India is on its way to becoming the largest emitter, despite low per capita emissions compared to the developed world. A helpful way to decompose the drivers of greenhouse gas (GHG) emissions is through the lens of the Kaya Identity, which captures the interaction of population, economic growth, energy use, and carbon intensity:

$$GHG\ emissions = Population \times (GDP/population) \times (Energy/GDP) \times (Emissions/Energy)$$

To understand how GHG emissions are likely to evolve, it is helpful to begin with projections of population growth. China's population is forecast to shrink from around 1,400 million today to below 800 million by the end of the century. That will mechanically translate into an over 40% decline in aggregate GHG emissions, other things equal. While this demographic trend could ease pressure on total emissions, the impact will depend heavily on how per capita emissions evolve in the context of economic growth, technological change, and policy. It is also reasonable to expect that energy intensity (energy/GDP) will continue to improve – over the past half century it improved on average by over 45 % globally – especially as China's economy progresses towards a larger share of the economy in services and higher value-added manufacturing. Also, carbon intensity (emissions/energy) is likely to decline significantly – over the past 50

1 This chapter draws on two reports on China's and India's net zero transitions, respectively. These reports engaged multiple research outfits and government entities in the two countries, but the views expressed here reflect only those of the authors of this chapter and not the institutions they represent. We are particularly grateful to Bengt Holmstrom, Ma Jun, Huang Haizhou and Cao Li (for their contributions to the China report) and Navroz K Dubash, Aman Srivastava, Easwaran J Narassimhan, Gagan Sidhu, Arjun Dutt and Amlan Bibhudatta (for their contributions to the India report). They contributed as full co-authors of the two respective underlying reports. We also benefited from comments at different stages from Danny Alexander, Arunabha Ghosh, Alissa Kleijnjenhuis, Bo Li, Martin Raiser, Ludger Schuknecht and Xing Zhang.

years it declined by over 12% globally – but this number is likely to be much higher going forward, given China’s progress in developing its renewable energy industry. Finally, the one driver that goes in the other direction – GDP per capita growth – is also likely to slow, shifting from the rapid expansion of earlier decades to the more moderate rates typical of advanced economies, as China continues its transition toward a more advanced stage of development. In sum, even if China does not proactively accelerate its energy transition, it is safe to forecast a significant decline in overall GHG emissions this century.

In contrast, India’s population is forecast to grow from around 1,400 million today to over 1,500 million by the end of the century. In addition, India’s economy is much less energy- and carbon-efficient. Finally, and most importantly, India has not yet experienced a similar big push growth period as China. If it follows in China’s footsteps, it will experience substantially higher GDP per capita growth over the coming decades. This is why India could well overtake China in total annual emissions over the longer term to become the largest GHG-emitting country in the world.

This chapter considers the net zero transition goals and policy frameworks of China and India as they currently stand, with a focus on implementation and the governance structure of each country. The economic and institutional circumstances of both countries are substantially different, which means that their net-zero transition pathways will require different policy and governance frameworks. China has already developed the largest renewable energy sector in the world, and while it is also the largest producer of electricity from coal-fired power plants, it has the technological know-how and financing capacity to undertake its energy transition without help from abroad. In contrast, India will need to import most of its renewable energy technology and will require financial support from advanced economies to scale up its renewable energy supply.

China’s current institutional framework is substantially different from India’s. China has a powerful central planning administration and can frame its policy objectives around five-year plans. China also has a large state-owned enterprise (SOE) sector, which co-exists with a vibrant and highly competitive private sector, as well as two major financial centres, one of which (Hong Kong, China) is the leading financial centre in Asia. Accordingly, a central challenge for the net zero policy framework of China is how to coordinate the policy actions of these different actors and sectors, and how to combine planning guidance – decentralised at the regional government and sectoral levels – with market incentives and financial market price signals.

India, as a federal state with powerful state governments and a pluralist complex, decentralised democratic structure, has different institutional processes. The central government sets the priorities and policy goals, but the green transition governmental architecture is less structured than in China. It runs through existing ministries and agencies, with much of the planning being left to the states. India is also at an earlier

stage of economic development and cannot rely on the same domestic resources to finance the transition as China. For much of India's investment effort to transition to renewable energy, external technical and financial sources are required, with multilateral institutions and the private sector both playing a key role.

Charting the pathway towards net zero requires that national authorities internalise the necessity for green governance across the policymaking apparatus, nationally and locally, across the economy and markets. Making green governance work effectively requires that ambitious goals be set across all spheres, and at all levels.

This chapter sets out a net-zero governance framework constructed of three pillars and lays out the ways in which they are applied in China and India.

## **2 A NET-ZERO GOVERNANCE FRAMEWORK**

The global transition to net-zero emissions is a multifaceted governance challenge. It cuts across sectors and levels of government, demanding unprecedented coordination and state capacity. Traditional governance often operates in silos with vertical accountability, which can lead to overlaps or gaps in addressing cross-cutting issues like climate change. Net-zero governance requires integrating efforts across ministries, agencies, and jurisdictions. While all countries face this challenge, each must find a 'best fit' approach suited to its own institutional context and capabilities. What works in one country may not directly transfer to another – strategies must be adapted to national economic structures, development stages, energy mixes, and political systems. Strengthening governance is foundational to the net-zero transition. In pursuing evolution in net-zero governance, we assume that policymakers are aiming to foster a predictable policy environment that encourages long-term investments in sustainable infrastructure, with the following key attributes:

- Alignment of national and regional policies with global climate goals, ensuring a coordinated approach to the net-zero transition.
- Enhanced public and private sector confidence in the feasibility and benefits of net-zero infrastructure projects.
- Equitable distribution of the costs and benefits of the transition, fostering social acceptance and support.

Our framework begins by identifying the optimal design of processes and allocation of responsibilities in a particular economic system and then applying the dimensions of state capacity and coordination. This chapter applies a conceptual framework built around three pillars of net-zero governance: planning, markets, and financial governance. The pillars represent mechanisms through which governments can drive the net-zero transition.

1. **Planning:** Strategic vision and policy alignment. Effective planning is the cornerstone of the net-zero transition, requiring a coherent, long-term strategic vision that aligns climate objectives with economic and social development goals that align with the Paris Agreement and the Sustainable Development Goals (SDGs). This pillar emphasises the integration of government interventions, including industrial policy, to foster structural transformation and ensure that key sectors are positioned to thrive in a low-carbon economy. Planning should encompass multi-stakeholder collaboration. It should include measures to enhance resilience and adaptation to physical and transition risks.
2. **Markets:** Enabling private sector participation and innovation. Markets are critical for mobilising private capital and driving innovation in the net-zero transition. Creating enabling conditions for private sector engagement requires help from government policy in guiding the development of competitive low-carbon industries. Leveraging market mechanisms and private sector innovation can help reduce emissions. Harnessing market mechanisms involves creating price signals (e.g., carbon pricing through taxes or emissions trading) that internalise the cost of carbon, as well as removing distortions that favour high-carbon options. It also includes facilitating the growth of green industries by mobilising private investment (e.g., through green bonds, public-private partnerships, auctions, and other mechanisms). The goal is to foster innovation ecosystems that support the net-zero goals and transition.
3. **Financial governance:** Strengthening institutions and regulatory frameworks. Robust financial governance is essential for ensuring transparency, accountability, and efficiency in the allocation of resources for the transition. Governments play important roles in supporting shaping regulatory frameworks, strengthening institutional capacities to support sustainable development, aligning the financial system with green transition goals, and managing climate-related financial risks. This pillar focuses on regulatory frameworks, public financial management, and institutional capacity in finance. Key elements include setting standards, encouraging transparency, redirecting public and private capital towards sustainable projects, and international cooperation on finance flows. Improvements in financial governance can help ensure that funding is available for the green transition.

The three pillars are interconnected and mutually reinforcing. A robust plan (Pillar 1) gives direction to markets and financial firms; vibrant markets (Pillar 2) spur innovation and investment that feed into planning goals; and sound financial governance (Pillar 3) supports the capital and risk management required to implement plans and scale market solutions. A balanced approach is needed, calibrated to each country's governance strengths and weaknesses.

All three pillars require enhanced state capacity and coordination. Net-zero plans should be supported by administrative efficiency, data-driven decision making, decentralised governance, transparency and accountability, and capacity building, including ‘just transition’ principles as cross-cutting enablers.

Empowering state and local governments and communities to take ownership of net-zero initiatives is part of good governance and can enhance the framework’s practicality. Robust monitoring, reporting, and verification systems are essential for tracking progress towards net-zero targets. Independent oversight bodies can audit climate policies and infrastructure projects, while digital platforms can improve transparency and citizen engagement. At the same time, training programmes for policymakers, regulators, and infrastructure planners on sustainable practices are essential, as are knowledge-sharing platforms for exchanging best practices. Finally, policies should protect workers and communities affected by the shift away from fossil fuels. Financial and technical support for retraining and reskilling programmes, along with investments in vulnerable regions, can ensure a just transition.

We believe China and India may provide useful case studies of governance approaches, and these countries’ experiences are used throughout the chapter to highlight differences and challenges. We recognise that countries’ green transition plans will be different in size, context, length, and breadth, depending on population demographics, level of development, and numerous other factors.

China is a unitary state with a powerful central planning tradition. The National Development and Reform Commission, five-year plans, and a well-developed net-zero planning architecture provide policymakers with many levers and amplifiers of policy. India, on the other hand, is a federal democracy where key responsibilities (such as land, electricity, and agriculture) are shared with states. Its climate strategy is diffused across diverse state governments and coordinated by the central government through persuasion, incentives, and cooperative frameworks rather than top-down mandates.

The following sections analyse each of the three pillars – planning, markets, and financial governance – in turn. For each pillar, we discuss strategy formulation and implementation mechanisms, and comment on stakeholder engagement. We then compare the two countries’ approaches and distill lessons for other emerging market and developing economies (EMDEs). The goal is to illuminate how the three-pillar conceptual framework can be operationalised in different contexts and the policy insights that emerge for governance of the green transition in emerging countries, referencing examples from China and India in each pillar.

## PILLAR 1. PLANNING: STRATEGIC VISION AND POLICY ALIGNMENT

Planning is the cornerstone of net-zero governance, providing a strategic vision that aligns climate action with economic and social development goals. Under this pillar, governments set targets (e.g., emission peaks, carbon neutrality dates), devise long-term pathways, and integrate climate considerations into broader development plans. Planning also involves establishing institutions and processes for cross-sector coordination and ensuring policies (in energy, transport, industry, etc.) are consistent with the net-zero trajectory. Effective planning requires balancing ambition with realism, and top-down direction with bottom-up input.

Planning and goal-setting for net-zero transition pathways, both short-term and long-term, should be coordinated across levels of government. National platforms should integrate regional, urban, and subnational priorities for climate finance and encourage wide stakeholder engagement and understanding of net-zero goals within communities and across markets and industrial sectors. Achieving net-zero targets requires leadership, clarity, and consistent communication of strategy and plans nationally and locally.

### Strategy formulation

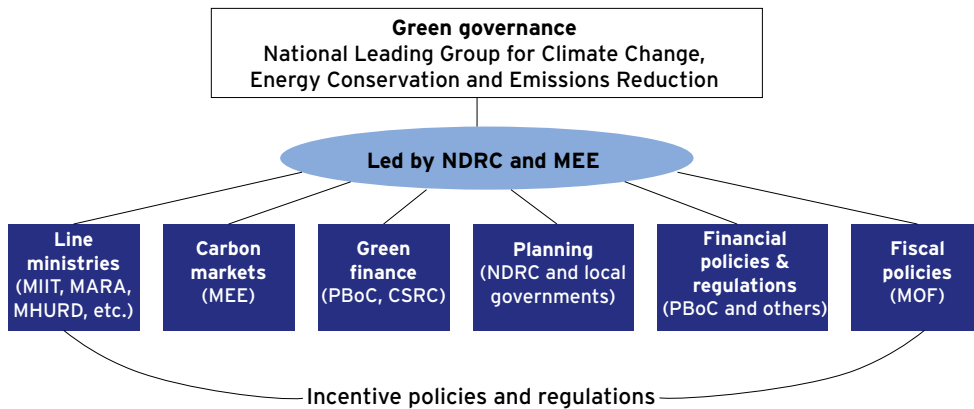
#### *China*

China's planning strategy for net zero is characterised by clear goal setting and integration into national plans. In 2020, China announced its Dual Carbon Targets (DCT) of peaking CO<sub>2</sub> emissions by 2030 and achieving carbon neutrality by 2060. These goals are embedded in the country's planning framework. Climate targets feature in China's Five-Year Plans (FYPs) – for example, the 14th FYP (2021–2025) includes binding targets for carbon intensity reduction and non-fossil energy share. As early as the 12th FYP, China made carbon intensity (CO<sub>2</sub> per unit of GDP) a constrained indicator in national development planning. As a result, local governments are assigned climate-related targets alongside economic goals, although enforcement and prioritisation vary depending on local development pressures. China's central planning agencies, particularly the National Development and Reform Commission (NDRC), play a leading role in setting and cascading objectives, though coordination with regulatory agencies such as Ministry of Ecology and Environment (MEE) remains important for effective implementation.

Industrial policy is broadly aligned with these goals. Strategic industries such as renewable energy, solar and wind, electric vehicles (EVs), and battery storage have been prioritised in plans and supported through mandates and subsidies, ensuring they iterate, innovate, grow, lower prices, and thrive under the government's transition plan.

The National Leading Group for Climate Change, Energy Conservation, and Emissions Reduction (hereafter referred to as the National Leading Group) has long served as China's top-level coordinating body for climate policy.<sup>2</sup> Following the announcement of China's carbon neutrality pledge in September 2020, the Leading Group on Carbon Peaking and Carbon Neutrality (LGCPCN) was established in May 2021 by the CPC Central Committee and the State Council. This dedicated group was created to strengthen the overall coordination, strategic deployment, and implementation of efforts related to carbon peaking and carbon neutrality. The LGCPCN introduced the "1+N" policy framework and led the establishment of corresponding provincial-level groups to enhance local coordination and develop tailored implementation plans. With the LGCPCN having fulfilled its mandate for top-level design and coordination of the DCT, the National Leading Group has resumed its overarching role in planning and coordinating China's climate policy.<sup>3</sup> The schematic in Figure 1 illustrates the institutional architecture supporting China's national net-zero strategy.

FIGURE 1 CHINA'S CLIMATE GOVERNANCE STRUCTURE



Source: Authors' illustration.

Line ministries play distinct roles in supporting the green transition. These include the NDRC, the Ministry of Industry and Information Technology (MIIT), the Ministry of Housing and Urban-Rural Development (MHURD), and the Ministry of Agriculture and Rural Affairs (MARA), among others. For example, the Ministry of Environment and Ecology (MEE) is primarily responsible for administering China's carbon markets. Financial regulators play a critical role in shaping the green finance ecosystem, such

2 See [https://www.gov.cn/ldhd/2007-07/09/content\\_678127.htm](https://www.gov.cn/ldhd/2007-07/09/content_678127.htm) (accessed 10 June 2025) and [https://www.mee.gov.cn/xxgk/hjyw/201808/t20180803\\_447653.shtml](https://www.mee.gov.cn/xxgk/hjyw/201808/t20180803_447653.shtml) (accessed 10 June 2025).

3 See [https://english.mee.gov.cn/About\\_MEE/Internal\\_Departments/202501/t20250106\\_1100027.shtml](https://english.mee.gov.cn/About_MEE/Internal_Departments/202501/t20250106_1100027.shtml) (accessed 10 June 2025). According to the MEE's official website, one of the core functions of its Department of Climate Change is to 'carry out the daily operations of the National Steering Group for Climate Change, Energy Conservation and Emissions Reduction.'

as the People's Bank of China (PBoC) leading the development of China's green finance framework and climate-related financial policies, and the China Securities Regulatory Commission (CSRC) overseeing capital integrity and is increasingly involved in regulating green bonds, ESG disclosures, and carbon-related financial products. Fiscal policies, including green budgeting and climate-related public finance measures, are handled by the Ministry of Finance.

Taken together, these bodies, ministries, and agencies determine the incentive policies and regulations that support the green transition. China has in place a National Expert Committee on Climate Change, which provides scientific and policy advice to the National Leading Group for Climate Change. The committee supports long-term strategy development by offering expertise on climate science, impacts, and response pathways.

China's approach centralises and coordinates net-zero planning at the highest levels of government. Climate goals are progressively embedded into planning instruments and policy processes across ministries, subnational governments, market mechanisms, and economic sectors. China's strategy formulation leverages its centralised governance: it can set long-term climate visions and immediately integrate them into national and subnational planning instruments. Five-year plans, sectoral strategies (for energy, industry, etc.), and regional development plans are moving into alignment with the pathway by translating the high-level targets (2030/2060) into intermediate milestones for provinces and industries.

### *India*

In 2021 at COP26, the Prime Minister announced India's target to reach net zero by 2070. In line with this target, India also updated its Nationally Determined Contribution (NDC) to include an interim goal for 2030: a 45% reduction in GDP emissions intensity from 2005 levels, a 50% power capacity from non-fossil sources, and the creation of an additional nature carbon sink of 2.5–3 billion tons CO<sub>2</sub> equivalent by 2030. India is on track to achieve its updated NDCs by 2030. However, beyond the overall net-zero commitment and these interim milestones, India has yet to fully translate its climate mitigation aspirations into a unified, detailed, and decentralised roadmap. As of mid-2025 there is, for example, no official date that India has committed to for its peak emissions, or for that matter an overall carbon budget that would limit its cumulative emissions. Some expert opinion suggest that India could achieve peak carbon by 2040–45.<sup>4</sup>

India's net-zero planning architecture is complex and dispersed, running from the central government, through ministries, agencies, and state governments. Even though central institutions have played brief roles at times, most climate policymaking has come from the ground up. It is individual sectors that really shape how fast and how deeply

4 "India sees carbon emissions peaking in 2040-45", Bloomberg, 3 November 2021 (<https://www.bloomberg.com/news/articles/2021-11-03/india-sees-carbon-emissions-peaking-in-2040-45>).

climate actions unfold, rather than decisions handed down from a single central body (Pillai and Dubash, 2021). Today, the key coordinating function is undertaken by the Executive Committee on Climate Change, which feeds into the Ministry of Environment, Forests and Climate Change.

In the absence of a tightly centralised plan, India's climate strategy has been articulated around a series of missions and policies. The National Action Plan on Climate Change (NAPCC), launched in 2008, outlined eight core "missions" (for solar energy, energy efficiency, sustainable habitat, water, forestry, etc.). Each mission has qualitative goals, and execution is assigned to a designated ministry. These missions have driven specific programmes (like large-scale solar parks, LED lighting distribution, forestry initiatives), and are operated somewhat independently.

Indian policymakers may consider the usefulness of institutional functions to strengthen strategy formulation and coordination. Proposals include setting up a High-Level Deliberative Body, chaired by the highest level of the executive branch and including relevant ministries and state representatives, to regularly deliberate on climate strategy. Another direction is the creation of an independent group comprising technical and analytical experts that would serve as a centre of climate change knowledge and analysis for the government and advise on pathways and monitor progress. Finally, an Executive Committee on Climate Change (ECCC) at the central government level would ensure that ministries' plans are aligned and would monitor implementation. Such institutional constructs aim to embed long-term climate strategy into India's institutional fabric by improving vertical (centre-state) and horizontal (inter-ministerial) coordination. The key point here is that the goal of any planning architecture should be to integrate net-zero considerations into the entire development planning at all levels.

## Implementation mechanisms

### *China*

To execute its climate plans, China relies on a combination of target-setting, policy mandates, and administrative oversight, provincial planning, market and non-market mechanisms. A primary mechanism is the allocation of climate and energy targets to subnational governments. For instance, after announcing the national DCT, the central government required all provinces and major cities to submit their own peaking action plans and ensure consistency with national goals. Provinces like Guangdong and Jiangsu, which are more developed, are expected to peak earlier than 2030, whereas others have later deadlines. This differentiation is itself planned. The central government also sets binding targets: it places caps on coal consumption growth, mandates reductions in energy intensity, and can pause approvals of high-emission projects if regions exceed energy use limits. Since the 1990s, China has reviewed high-energy-consumption projects and used total energy intensity limits as part of its implementation toolkit.

Elements of implementation and oversight occur at the national level, with processes determined by the National Leading Group, ministries, and agencies. Implementation is driven by provincial and local leaders, who play a significant role in determining how net zero policies are rolled out across regions, cities and communities.

### *India*

Implementation of climate-related policies reflects India's federal governance structure and its market-oriented approach. Rather than relying on binding emission targets on states or firms, India uses policy instruments and schemes to operationalise its climate objectives. For example, to achieve its renewable energy targets, India employed competitive auctions under the National Solar Mission. The central government (through agencies like SECI) conducts bidding rounds where private developers compete to build solar and wind projects at the lowest tariff. This market-based implementation has been highly successful – driving down solar power costs and leading India to install over 100 GW of renewables (as of 2022) and meet its 40% non-fossil capacity goal well ahead of the 2030 deadline.

The government applies regulatory mandates with flexibility, epitomised by the Perform, Achieve and Trade (PAT) scheme (discussed further in Pillar 2). Under PAT, energy-intensive industrial and power sector units are given specific energy efficiency improvement targets (a form of intensity cap). Those who exceed their targets earn tradable Energy Saving Certificates, while those who fall short must buy these certificates, or pay penalties. This mechanism, implemented by the Bureau of Energy Efficiency, in effect creates a cap-and-trade system for energy intensity. Since its launch in 2012, PAT has expanded from 478 to 956 designated industrial consumers across 13 sectors, achieving energy savings and emission reductions. The scheme's trading element provides flexibility and cost-effectiveness in compliance – a pragmatic implementation approach in a developing country context.

Coordination mechanisms in India's implementation are evolving. Currently, climate-related actions are coordinated through existing structures (for example, the Ministry of New and Renewable Energy coordinates renewables, the Ministry of Environment, Forest and Climate Change oversees NDC reporting). Additionally, India also relies on international partnerships – such as the US-India Climate and Clean Energy Agenda 2030 partnership, the India-Denmark Green Strategic Partnership, India UAE/Saudi Arabia cooperation, etc. – for implementation support with renewable energy deployment and EVs, or financing agreements with multilateral banks for specific projects (solar parks, sustainable transport, etc.). In summary, India's implementation approach is a mix of national schemes, market-based mechanisms, and collaborative initiatives with subnational actors and global partners. This approach builds on, and is adapted to, an existing bureaucratic architecture, but it does not yet clearly articulate overall limits on emissions and controls to prevent carbon leakage.

## Stakeholder engagement

### *China: Central planning and stakeholder buy-in*

In a centrally planned system, stakeholder engagement in planning is predominantly institutional (within government and state sectors). Key stakeholders for China's climate planning are government entities at various levels and state enterprises. The central government engages provincial governments through the target responsibility system – negotiating and assigning climate targets – and provides written guidance.

Provinces and cities are important stakeholders and have enthusiastically responded by creating their own “carbon peaking leading groups” and drawing up detailed action plans, with provinces able to showcase green leadership. For example, the city of Chongqing set ambitious goals to peak by 2028 and reach near-zero emissions by 2050, positioning itself as a pilot and model for others.

Another set of stakeholders are SOEs and industry associations. The government actively consults major SOEs in power, coal, steel, and so on to ensure climate targets are feasible and to solicit input on technology pathways. These entities have technical expertise and will carry out much of the transition (e.g. building renewables, shutting down old plants). Engagement with academia and expert communities is also observed – Chinese research institutes model pathways and feed analysis into planning (for instance, Tsinghua University's team provided landmark studies on peaking and neutrality that informed policy). Civil society plays a role in China's policy process; the government uses public communication to build support for policies (for instance, propagating the concept of ‘ecological civilisation’ and framing net zero as part of national rejuvenation).

Stakeholders in China's climate-related markets include regulated companies, financial intermediaries, and government regulators. Engagement via capacity building and phased introduction is seen. For instance, when launching the ETS, the government engaged power companies in learning-by-doing during pilot phases. Negotiation with industry takes place – the initial benchmarks in the ETS were set mindful of needed buy-in from power companies, and to adjust compliance costs. As the ETS evolves, pricing and compliance can be adjusted. A gradual approach allows stakeholder management, ensuring industries support the carbon market and net-zero goals and plans.

Financial stakeholders (banks, investors) are engaged as China develops green financial markets and products. The PBoC and other regulators consult with banks on guidelines for green loans and bonds. In response, Chinese banks have started issuing transition bonds and sustainability-linked loans, aligning with green transition frameworks.

An important stakeholder group is tech innovators and entrepreneurs. China's government has fostered public-private collaboration in innovation hubs (e.g., in electric mobility, battery tech, hydrogen). By setting clear market signals (such as future New Energy Vehicle (NEV) credit requirements), the government engaged automotive companies and startups to invest in EVs early. Similarly, solar PV companies were

supported through feed-in tariffs, which motivated investments in manufacturing. As subsidies recede, stable policy – like curtailment reduction and fair grid access for renewables – matters. The government is mindful of a need for certainty and stability in markets. Additionally, through industry associations (like China Electricity Council, China Iron & Steel Association), stakeholders provide feedback on market policies (e.g., how an ETS expansion might affect them or what cost containment measures are needed).

#### *India: Multilayered interactions and engagement*

Stakeholder engagement in green planning is diverse, given India's federal structure. The range of stakeholders includes central ministries, state governments, private sector companies, civil society organisations, and international partners.

Industry has generally been consulted on policy design. For example, the design of PAT and the upcoming carbon market involved consultations with the industries that would be regulated. The Bureau of Energy Efficiency worked with industry experts to set realistic energy intensity targets. For the future carbon market, there are stakeholder committees that include representatives from the power, steel, and cement sectors to co-develop the rules.

Market participants are consulted by regulators. Entities like the Indian Energy Exchange (IEX) and regulators like Central Electricity Regulatory Commission (CERC) are core stakeholders for trading schemes. Investors and the financial community have a voice via consultations on green finance (such as framing green bond guidelines).

The government actively engages with the private sector. As the 'renewable rush' in India is led by private investment, policymakers have involved industry bodies in crafting policies, including renewable energy auctions and manufacturing incentive schemes (e.g., the Production-Linked Incentive for solar PV manufacturing was designed in consultation with industry players). Public-private task forces permit dialogue on clean energy, and businesses are often invited to voluntary initiatives (such as the Alliance for Climate Action or sectoral low-carbon transition roadmaps). Many Indian companies have made their own net-zero pledges, and the government has urged them to align corporate action with national goals. Civil society and experts also participate in India's climate discourse. NGOs and research institutions frequently provide input on climate policy – for instance, in drafting the Long-Term Low Emissions Development Strategy submitted to the UNFCCC.

Importantly, India has launched the LiFE (Lifestyle for Environment) initiative to engage with citizens in climate-friendly practices and demand-side changes. While not directly a planning tool, LiFE represents an effort to socialise the country's climate aspirations, solicit civil society participation (through simple actions like saving energy, using public transport, and so on), and to use behavioural mechanisms to nudge consumer choices in support of the country's green transition pathway. LiFE also offers a potential basis for organizing international collaboration.

## The role of provincial and state governments

### *China's central-local climate governance and the role of provinces*

Chinese provinces play a key role in the implementation of climate policies. Under China's "target responsibility system", many of the central government's key climate and energy targets are allocated to individual provinces, with provincial leaders responsible for fulfilling them. To pursue green targets at the provincial level, each region has its own Leading Group on Climate Change, chaired by top provincial leaders.

Provincial governments play an influential role in the planning and implementation of net-zero policies. Local governments generate their own revenues and provide budgets and other resources for implementing national policies, including DCT targets. Given this pivotal position, provincial government decisions can speed up or slow down the achievement of DCT targets and decarbonisation. Moreover, because provincial governments run companies in key industries such as power generation, local SOEs are essential to securing local and national goals.

National green mandates coexist with local provincial goals and implementation plans – a careful balance between central control and local prerogatives. National centralised green governance planning authorities understand the need to reflect provincial realities, and assist provinces that, for reasons of geography, demography, or relative level of development, may be falling behind in achieving net-zero goals.

At the provincial level, disparities exist in terms of progress toward the 2030 carbon peaking goal (based on carbon intensity). For instance, reports suggest Xinjiang, Inner Mongolia, Ningxia, Heilongjiang, and Liaoning are lagging, especially considering that they were also among the most carbon-intensive provinces in 2020. In contrast, Beijing, Shanghai, and Guangdong are in the lead.

Plans are designed by the Leading Group and NDRC. Innovation by provincial leaders and a 'trickling up' of new approaches is also evident. Eleven provinces have developed plans for addressing and adapting to climate change as part of the 14 FYP cycle. Provinces have also, for instance, designed local plans to support electrification and multimodal transport. A pronounced shift to rail and shipping for medium- and long-haul transport is also being seen across provinces (Dai et al., 2024). Provinces are electrifying public vehicle fleets to achieve DCT goals. Addressing building standards is also underway, with 26 provinces implementing low-carbon initiatives for green buildings.

China's green and climate policy implementation includes local green finance pilots, by designating zones (e.g., in Zhejiang, Guangdong, and Guizhou provinces) for green finance innovation. In these zones, local authorities and financial institutions have experimented with new products like emissions rights pledging (using carbon allowances as loan collateral), green insurance, and blended finance for green projects. Successful pilots get rolled out nationally.

These are just a few indicative examples of the multifaceted planning and implementation of plans and pathways at the provincial level. Securing net-zero and DCT goals requires provincial ownership of and design of the localised plans. This is underway as provinces make net-zero plans. Practically all are engaged in the implementation process.

### *India's cooperative federalism model*

Indian states need to be equal partners in the transition to a low carbon pathway. States have constitutional authority over certain sectors, can design policies for their regions' needs and construct their own localised policy implementation approaches. But the public good nature of climate mitigation calls for the internalisation of the positive externalities from emissions abatement through greater coordination and collaboration across states. Federal and state-level policies need to reflect the different speeds and needs of states, their economies, and populations. But at the same time, the potential for large spillover benefits across states calls for greater cooperation and inter-state transfers. Central government planning recognises these differences across states, but has not focused sufficiently on the benefits to all states from individual state mitigation policies.

India's states control local infrastructure and utilities, so the central government works through cooperative federalism – providing financial incentives or technical support for states to implement climate-friendly projects. State governments are best placed to design net-zero plans and have jurisdiction over key policies and tools essential to a smooth transition. At the same time, states differ significantly in terms of endowments and capacity to implement complex policies to harness renewable energy. Some states are ahead in the installation of renewables, while in others fossil fuels still dominate.

The central government uses various mechanisms and approaches. For instance, the central government's "24x7 Power for All" initiative pressed states to integrate more renewables into their power mix and reduce transmission losses, with funding linked to progress. A push for rail electrification and a shift to public transport in cities (through the Smart Cities Mission and metro rail projects) aims to align urban development with emissions goals.

The central government encourages local administrations to formulate State Action Plans on Climate Change (SAPCCs) aligned with national objectives. The states have jurisdiction over critical areas (land use, local transport, agriculture) and are best placed to design green plans for their regions and communities.

Implementation can often take the form of state-specific policies and experiments. Several Indian states have announced their own renewable energy policies, electric vehicle policies (such as Delhi's EV policy providing purchase incentives and charging infrastructure rollout), and climate action plans that include adaptation and green job components.

State capacities vary, and not all have updated plans reflecting the 2070 net-zero goal. Some states, like Gujarat, Kerala, and Maharashtra, have announced net-zero targets but face unique challenges and opportunities. Gujarat intends to achieve net zero by 2070, but it will have to ensure its large industrial base has access to high-quality and affordable power. Similarly, Kerala aims to attain net-zero emissions by 2050 and meet 100% of its energy requirements through renewable energy sources by 2040. However, Kerala is heavily reliant on imported power so will be dependent on other states to achieve the target.

Within India, there are significant differences in the rate of adoption of green solutions. For example, in FY2020-21, solar and wind accounted for around 29% of annual electricity generation in Karnataka, 20% in Rajasthan, 18% in Tamil Nadu, and 14% in Gujarat. India's renewables-rich states already have a higher share of variable renewable energy (VRE) than most countries. International Energy Agency data show that the share of solar and wind in India's ten renewables-rich states (Tamil Nadu, Karnataka, Gujarat, Rajasthan, Andhra Pradesh, Maharashtra, Madhya Pradesh, Telangana, Punjab, and Kerala) is significantly higher than the national average for 2024 of 10% (IEA, 2021).

There is considerable experimentation and innovation at the state level. For instance, Indian states and cities are considering localised cap-and-trade mechanisms for air pollutants (e.g., particulate matter trading pilot in Gujarat). These could build capacity for GHG trading. The implementation know-how from PAT (setting baselines, MRV systems, registry) is an asset as India moves into carbon trading. One challenge in implementation is the need to harmonise measurement: converting PAT's energy metric into CO<sub>2</sub> for trading requires establishing emissions baselines for new sectors and ensuring additionality of credited reductions.

States are using market mechanisms through which they can raise finance (some states have issued green bonds, such as Uttar Pradesh for tertiary water treatment, and Maharashtra for urban sustainable transport). The central government and multilateral agencies are supporting building state capacity to prepare bankable green projects that can attract funding. Ongoing federal expertise and support is expected to develop state action on the links between the green transition and financial markets.

## **PILLAR 2. MARKETS: ENABLING PRIVATE SECTOR PARTICIPATION AND INNOVATION**

Markets play a pivotal role in driving the net-zero transition by mobilising private capital, fostering innovation, and efficiently allocating resources. Through price signals, competition, and entrepreneurial activity, markets can accelerate the deployment of low-carbon solutions at scale and pull targets forwards as firms seize new green opportunities. Governments facilitate this by creating the right incentives and disincentives – for

example, putting a price on carbon to internalise environmental costs, removing subsidies for fossil fuels, or offering tax breaks for clean technologies. Market-based approaches complement planning: while planning sets the direction, markets provide flexibility and harness decentralised decision-making power.

## Strategy formulation

### *China*

China's net-zero strategy acknowledges that market signals are necessary to achieve deep decarbonisation, alongside government planning. Official policy documents emphasise a dual approach – leveraging both government guidance and market forces – while allowing market mechanisms to play a decisive role in resource allocation for the green transition.

This commitment has led to the development of China's national carbon market. Early strategy formulation involved piloting emissions trading systems in seven regions from 2013-2017. In 2021, a nationwide ETS was established. The aim was to leverage market-based carbon pricing to control emissions in a cost-effective way, especially in the power sector. By 2021, the national ETS was operational, initially covering around 40% of China's emissions (power sector) producing four billion tons of CO<sub>2</sub>. It is set to expand to other industries. China's ETS is an intensity-based scheme with free allocated allowances and the cap adjusted ex post – both based on actual production levels.

Beyond carbon trading, China's market strategy includes green finance markets (discussed more in Pillar 3) and encouraging competition in 'cleantech' sectors. China uses industrial policy to create domestic markets for new technologies – for example, feed-in tariffs and later competitive auctions for renewable energy guaranteed a market for solar and wind, which helped domestic firms grow and innovate.

Similarly, China has a well-developed strategy to speed electrification of transport. Generous EV purchase incentives and mandates (i.e., the zero-emissions vehicle credit system) rapidly created the world's largest EV market, which in turn drove battery innovation and economies of scale. The strategic goal was to create initial conditions for markets (through subsidies and mandates) and then gradually let competition drive costs down and adoption up. China tapers subsidies once tech is competitive (e.g., it phased out solar feed-in tariffs in favour of auctions, and EV subsidies are being reduced as the market matures). As of 2025, many observers believe China has succeeded and now leads the world in EV, battery innovation, solar PV, and other green technologies, driven by a combination of effective industrial policies, non-market and market mechanisms, as well as targeted incentives and disincentives and industrial policies.

For example, China has innovated around 'markets for pollution control' – such as trading schemes for SO<sub>2</sub> and NO<sub>x</sub> in the past, and pilots for water usage rights trading. These market tests then feed into carbon market design. China's 2021 guidance on using market mechanisms to achieve carbon peaking and neutrality calls for "establishing a unified

national carbon market, expanding green power trading, and developing ecological product markets”. China’s market pillar strategy is one of progressive introduction: start with key sectors (e.g., power), refine rules, then broaden to more sectors and pollutants, all while ensuring these markets are well-regulated and align with the country’s industrial development goals.

### *India*

India’s strategy for harnessing markets in the green transition emphasises competition and private investment in clean energy, as well as gradually moving towards explicit carbon pricing mechanisms. Historically, India has been cautious about carbon pricing because of equity concerns (low per-capita emissions and ongoing developmental needs). Instead, it has focused on ‘non-market’ policies like renewable targets, energy efficiency standards, and fuel economy norms.

However, over time the policy narrative has shifted to recognise that carbon markets and pricing can complement existing policies. The government’s strategy now includes establishing a domestic carbon market framework. In 2022, India amended its Energy Conservation Act to create a statutory basis for carbon credit trading. The emerging Indian Carbon Market (ICM) strategy envisions an umbrella market that integrates the PAT scheme and other sectoral efforts into a coherent system trading carbon-equivalent credits. The ICM aims to have a compliance market (obligations for large emitters) and a voluntary market (for others to trade offsets), eventually possibly linking with international carbon markets. The ICM is expected to be operational in FY2025-26.

India’s strategy relies on markets to attract inward and domestic investment for renewables and infrastructure. The country has set up market-friendly policies such as transparent auctioning for renewable energy projects, standardised power purchase agreements, and, more recently, green open access rules that allow corporate buyers to directly procure green energy. These measures are intended to ease market entry and scale up deployment by private actors. The success of this strategy is visible in the high level of private sector participation in renewables (over 90% of renewable investments in India are private).

The government is leveraging global markets – for example, it permitted 100% foreign direct investment (FDI) in renewable energy, tapping international capital and expertise. It also joins international market-based initiatives, such as the Article 6 discussions under the Paris Agreement, to potentially export credits or attract carbon finance through bilateral deals. Domestically, India introduced a Renewable Energy Certificate (REC) market a decade ago to help states and utilities meet renewable purchase obligations via trading, although that market faced challenges such as price caps and oversupply.

Finally, India’s climate strategy further includes a role for fossil fuel pricing. The government increased the coal excise duty in 2014-2018, which functioned as a modest carbon tax (with revenues going towards a clean energy fund). Moreover, high taxes on petroleum fuels in India make petrol and diesel expensive, and while primarily for

revenue, also act to discourage excessive use and encourage switching to EV alternatives. Going forwards, aligning price signals with climate goals (perhaps by rationalising these taxes or introducing a carbon surcharge) is part of the strategic policy conversation. In summary, India's market pillar strategy relies on competitive markets to drive down clean tech costs and encourage adoption (with great success in renewables), and to incrementally adopt carbon trading and other price-based instruments to steer the economy onto a lower-carbon path.

## Implementation mechanisms

### *China*

China's ETS currently covers over 2,000 power plants, making it the world's largest carbon market by volume of emissions. Implementation of the ETS has been careful and phased. Initially, instead of an absolute cap, it uses a rate-based allocation (emissions intensity benchmarks per unit of electricity) to set allowances, reflecting China's focus on reducing intensity rather than absolute emissions in the near term. Companies that generate power more efficiently than the benchmark can sell surplus allowances, and those less efficient must buy.

While the carbon price in the first year hovered around a modest CNY 40 (around \$6) per ton – and had limited impact on immediate emissions reductions – the market has yielded important data transparency and established the institutional infrastructure for expansion. In less than three years, the carbon price more than doubled, surpassing CNY 100 per ton (around \$14) for the first time in April 2024. Plans are underway to further broaden the ETS to additional sectors (coverage has already been extended to the cement, steel, and aluminium industries) and to gradually refine it into a more stringent cap-based system over time.

China uses market-based measures. Green power trading has been introduced under which renewable generators and consumers can trade green power certificates, allowing market determination of renewable energy value beyond subsidies. Pilot green power markets enable companies to directly buy renewable energy, which encourages additional renewable generation.

Similarly, the government has trialled carbon offset mechanisms, including a China Certified Emissions Reduction (CCER) programme where companies can invest in approved emission-reducing projects (such as methane capture or forestry) and receive credits to offset some emissions. Although the programme was suspended to revise its regulatory framework, it was reactivated in January 2024 and has since been integrated into the national ETS as an offset mechanism, linking market-driven project financing to compliance needs.

Continuing to innovate, China has set up national carbon trading exchanges (in Shanghai and Wuhan for the ETS) and encouraged development of financial products around carbon. For example, carbon futures or forwards contracts are being explored to help entities hedge price risk. The existence of these instruments is turning emissions reduction into a tradable commodity, potentially engaging financial market players in climate action.

The government is also using competition policy and market liberalisation in the energy sector to serve the net-zero agenda. China has introduced competition in power generation (e.g., renewable generators competing for grid access or quota). The government's reforms in the power market, such as direct power purchase agreements and spot market pilots, may indirectly benefit clean energy by breaking the monopoly of coal power under fixed contracts.

Work is ongoing to remove distortions. China has begun cutting fossil fuel subsidies and is considering electricity pricing reforms to reflect environmental costs. If industrial power tariffs incorporate carbon costs from the ETS, that is a market signal to industries to adopt cleaner processes.

In summary, China's implementation of market mechanisms is characterised by central planning, direction, and scaling: start with limited scope, ensure the market infrastructure works, then expand scope and tighten caps. This pragmatic approach will continue as China progresses toward its peak and decline phases.

### *India*

India's implementation of market mechanisms has various facets. Renewable energy auctions, overseen by SECI and other agencies, are used for solar and wind projects, where developers bid tariffs at which they can supply power. The open competitive dynamic has led to record-low bids, effectively translating global technology cost drops into cheaper power for India. These auctions are technology-specific and now also include auctions for round-the-clock renewable power and hybrid projects (wind + solar + storage), pushing innovation in project design. The success of auctions means India will continue using them to achieve its target of 500 GW of non-fossil capacity by 2030. Auctions have also been introduced for allocating new transmission lines for renewables, bringing competition in grid infrastructure. Another innovative mechanism is the tripartite agreement between the central government, state governments, and the central bank. Under this agreement, in the case of default by a state-owned power distribution company, the central government can withhold financial assistance to the state government.

India's Perform, Achieve, Trade (PAT) is an implementation of a market-like mechanism for energy efficiency. In its multiple cycles, PAT has resulted in trading of Energy Saving Certificates (ESCerts) on the Indian Energy Exchange (IEX). By 2018, over 3.8 million ESCerts were traded. The market aspect has generally kept the cost of compliance reasonable and stimulated some companies to overachieve and monetize extra savings.

Building on PAT, the Indian Carbon Market (ICM) will use the PAT infrastructure to issue tradable carbon credits (moving from energy-only to CO<sub>2</sub>-equivalent units). Implementation of ICM is in progress: a regulatory Steering Committee led by the Bureau of Energy Efficiency is developing the rules, and CERC will regulate the trading platform. This cross-agency setup is meant to ensure robust oversight of the emerging carbon market.

Indian companies have participated in voluntary carbon markets, often by selling credits from renewable energy or forestry projects internationally (e.g., under the Clean Development Mechanism historically, and now via voluntary standards). The government's response is to create a framework to govern these to avoid double-counting and ensure quality. Under the carbon market mechanism, a Green Credit Program is also being conceived to incentivise other voluntary sustainability actions (such as water savings and waste management) and to issue credits – broadening market-like incentives beyond the strict confines of the carbon market mechanism.

Steps are being taken to reduce market distortions in fossil fuel prices. India deregulated petrol and diesel prices (allowing them to float with global prices), and drastically reduced subsidies on gasoline and diesel. Further reduction of subsidy can be considered as phasing in of more renewables enhances energy security. India also instituted a small carbon-like tax on coal which sends a price signal, albeit modest (around \$3/ton CO<sub>2</sub>). While not a tradable market, this tax mechanism internalises a small part of the carbon cost. Additionally, India is exploring market mechanisms in the power sector – such as real-time power markets and ancillary service markets – to improve efficiency, which indirectly helps renewables (as they can provide services and get paid, making them more viable).

Finally, while not a market mechanism per se, increasing requirements for companies to disclose climate-related risks and emissions – driven by Securities and Exchange Board of India (SEBI) and Reserve Bank of India (RBI) guidelines – create quasi-market pressure by enabling investors to factor climate performance into their portfolio decisions. This is turning corporate climate action into a competitive factor in capital and product markets.

In leveraging market mechanisms, India faces capacity and design challenges – for example, ensuring the new carbon market has the right balance of supply and demand to create a meaningful price and that it complements, rather than duplicates, other policies. If done well, India's carbon market could become a major vehicle for channelling carbon finance into the country, given the potentially lower-cost abatement opportunities available. In essence, India is moving from an era of implicit pricing (through regulations and subsidies) to explicit carbon pricing and robust market instruments – a significant implementation shift for the coming decade.

### **PILLAR 3. FINANCIAL GOVERNANCE: STRENGTHENING INSTITUTIONS AND REGULATORY FRAMEWORKS**

Financial governance in the context of the green transition refers to aligning the financial system – public finance, private finance, and regulatory oversight – with climate objectives. It involves ensuring transparency (so that green investments are clearly defined and risks are disclosed), accountability (so that financial flows support stated policy goals), and the efficient allocation of resources to sustainable projects. This pillar also encompasses building the capacity of institutions (finance ministry, central bank, financial regulators, development banks) to facilitate the transition. In essence, it is about greening financial decision making at all levels: budgeting, banking, capital markets, and international finance.

Improved national financial governance can support the mobilisation of domestic and international resources for the green transition. In many countries, as much as two-thirds will have to come from domestic sources. In most countries, international capital flows will be required as national and local finance of the green transition will fall short of what is needed

Resource mobilisation must be coordinated through country-owned platforms implementing comprehensive growth and development strategies. This needs to include encouraging the use of common environmental, social, and governance standards along with transparency and competitive procurement.

Countries with strong, stable, transparent, well-understood and credible plans, and a supporting financial governance architecture of institutions and policies, can improve their access to domestic and international funding for the green transition. This is why pillar three is so important to development and as well as to net-zero goals, national, and local pathways.

#### **Strategy formulation**

##### *China*

China recognised early that achieving its climate goals requires a massive redirection of finance. The strategy for financial governance has actively shaped financial flows using both regulatory mandates and market innovation. In 2016, China issued its first national Guidelines for Establishing a Green Financial System, which at the time were pioneering and set a strategic blueprint including green credit, green bonds, environmental risk analysis, and disclosure.

The PBoC is a central actor in formulating this strategy, in coordination with ministries like the Ministry of Finance and Ministry of Ecology and Environment. A strategic element was defining what counts as ‘green’ – China developed a Green Bond Endorsed Project Catalogue in 2015 (revised in 2021 to exclude fossil projects) to guide investors, and criteria for green loans in 2018. This taxonomy design process is a core part of the strategy to avoid greenwashing and direct funds appropriately.

Another strategic aspect is leveraging China’s state-driven financial system. With large state-owned banks and policy banks, China can directly influence lending patterns. The strategy includes incentivising banks – for example, the PBoC introduced a performance evaluation for green finance, under which banks are scored on how much they lend to green projects. This encourages banks to prioritise green over brown lending. Additionally, the PBoC has rolled out targeted refinancing facilities, providing low-cost funds to banks for lending to approved green sectors (e.g., a Carbon Reduction Facility launched in 2021). By lowering funding costs for green projects, the state nudges capital towards them.

China’s financial strategy emphasises risk management. It integrates climate considerations into financial stability assessments, stress-testing banks for climate risks and exploring how to manage transition risks if, for example, assets like coal plants become stranded. The goal is to prevent systemic shocks during the net-zero transition and to ensure banks remain stable.

Internationally, China’s strategy positions the state as a leader in green finance. China co-founded the Network for Greening the Financial System (NGFS), a coalition of central banks, and co-chaired work on a “Common Ground Taxonomy” with the European Union. This strategic move helps align Chinese and global standards, facilitating cross-border green investment flows, and aids Chinese firms in attracting foreign environmental, social, and governance (ESG) investment by adhering to globally recognised criteria.

In summary, China’s financial governance strategy is proactive and state-led: define standards, require or incentivise financial institutions to follow them, innovate with monetary tools to support climate, and engage globally to mobilise additional finance while shaping the rules.

### *India*

India’s green financial governance strategy is rapidly evolving. Historically, climate was seen largely as an environmental or energy policy issue, with less involvement from financial regulators. This has changed as physical and transition risks have risen, along with the cost (economic and societal) of climate change. The scale of the investment needed is considerable. One estimate suggests that \$10.1 trillion cumulative investment will be needed by 2070 (Singh and Sidhu, 2021). Achieving this level of financing will need a combination of sources – domestic and international, public and private sector, commercial banks, and capital markets.

Leveraging public and private sources of international finance is essential to close India's investment gap. India's domestic resources are insufficient to secure state policy green goals, and the country's green investment needs are significant. Table 1 illustrates a forecast of the amount required.

**TABLE 1 INDIA'S INVESTMENT REQUIREMENTS, OPPORTUNITIES AND CHALLENGES TO ACHIEVE NET ZERO BY 2070 (CONSTANT 2020 USD BILLIONS)**

	Investment requirement	Mobilisable from conventional sources ( <i>opportunity</i> )	Investment gap ( <i>challenge</i> )	Investment support ( <i>assistance</i> )
<b>Power</b>	8,412	5,314	3,098	1,239
<b>Mobility</b>	198	198	--	--
<b>Industrial</b>	1,494	1,046	448	179
<b>Total</b>	10,103	6,558	3,546	1,419
<b>Average annual</b>	202	132	70	28

Source: Singh and Sidhu (2021).

Mobilising international climate finance is crucial to close this gap. This includes seeking concessional finance from multilateral development banks, issuing dollar-denominated green bonds by Indian entities, and advocating for mechanisms such as the Climate Finance Leadership Initiative (CFLI) to focus on India. India has often highlighted the \$100 billion climate finance commitment by developed countries, framing its climate actions partly on receiving its share. Thus, part of its strategy is diplomatic – pushing for more grants, loans, and partnerships that can funnel foreign capital into Indian clean projects. Domestically, the government is considering opening sectors further to foreign investment and easing investment norms for green projects (for example, renewable energy projects are an automatic route for FDI).

Domestically, greening the banking sector is supported by the RBI by incorporating climate into its regulatory mandate. The RBI joined the NGFS in 2021, signifying a commitment to learn and act on green finance. India has updated its Priority Sector Lending (PSL) guidelines to include renewable energy (and compressed air energy storage, etc.), meaning banks must allocate a certain percentage of their lending to these sectors or face penalties. This directs credit to green projects. The RBI's strategy also includes developing frameworks like the Green Deposit Scheme (GDS) to channel retail and corporate deposits into green lending by banks. Excluding fossil projects from these deposits by regulation ensures the money truly supports net-zero sectors.

The government is also developing domestic green capital markets. It has embraced raising finance through green bonds. In FY2022-23, India issued its first Sovereign Green Bonds, signalling to the market the sovereign's commitment and providing a benchmark for pricing. In the subsequent years there has been a sizeable scaling up of Sovereign Green Bonds issuance. Relatedly, the Finance Ministry has created a Green Bond Framework aligned with international principles. The goal is to help build a yield curve for green finance and attract ESG-focused investors.

SEBI, the securities regulator, has since 2017 laid out guidelines for green debt securities for corporates and required ESG disclosures for the top companies. Strengthening disclosure norms – for example, mandating Task Force on Climate-related Financial Disclosures (TCFD)-like reporting – is part of the strategy to improve transparency and thus investor confidence.

On the fiscal side, India's strategy includes increasing budgetary allocations for climate-related expenditures (e.g., in annual budgets there is now a section on climate action). Schemes like the National Green Hydrogen Mission (with \$2 billion-plus allocated) or incentives for EVs are structured to leverage private investment – indicating a strategy of using limited public funds to unlock larger market finance.

Finally, on risk management and regulation, the RBI has drafted new guidelines on climate risk and sustainable finance. Strategically, the RBI plans to ask banks and financial institutions to assess climate risks in their portfolios and perhaps adjust asset risk weights based on climate impact (penalising carbon-heavy loans and favouring green loans). This would be a direct way to tilt bank incentives. In addition, integrating climate scenario analysis in stress testing is also under review.

In summary, India's strategy for financial governance is to gradually but steadily integrate climate into the mandates of financial institutions, create conducive conditions for green finance (standards, incentives), and actively seek international support. This represents a shift from treating climate as purely an environmental issue to a macroeconomic and financial stability issue.

## Implementation mechanisms

### *China*

Implementation of China's green financial strategy includes the following:

**Green credit guidelines:** Starting in 2012, the CBRC (the bank regulator) issued green credit guidelines for banks. By 2021, Chinese banks had approximately ¥14 trillion (over \$2 trillion) in outstanding green loans. Banks have responded to this by setting up internal green finance units and creating specialised green products.

**Green finance evaluation:** As noted, the PBoC conducts an evaluation of banks' green finance performance, essentially rating banks on how 'green' their lending is. This carrot-and-stick approach has resulted in a rapid expansion of green lending (26% year-on-year growth as of mid-2021).

**Monetary policy tools:** In 2021, the PBoC launched the Carbon Emissions Reduction Facility (CERF) – a refinance scheme whereby it provides funds to banks at a low rate (1.75% per annum) for loans that go to carbon-reduction projects (renewables, energy efficiency, etc.). Regulatory support further reduces the cost of lending, shifting incentives towards financing climate-aligned projects. The PBoC also has increased its targeted re-lending quota to support the clean and efficient use of coal and has used loan quota guidance (window guidance) to direct more credit to strategic green sectors.

**Green bonds:** China has become one of the world's largest green bond markets, and loan volumes continue to grow rapidly. Implementation has been facilitated by regulators allowing fast-track approvals for green corporate bonds and local governments issuing green municipal bonds. By 2021, ¥1.1 trillion in green bonds were outstanding. Chinese exchanges list green bonds, improving visibility. Some localities have given tax breaks or interest subsidies for green bonds to encourage issuers.

**Mandatory disclosure requirements:** The government is phasing in mandatory environmental information disclosure for listed companies and bond issuers. Pilots require firms in heavy industries to disclose pollution and carbon data, and full mandatory disclosure for all listed companies is expected soon. These requirements are implemented via securities regulation and stock exchange listing rules. Investors, empowered, can then select where they want to put their funds, and choose brown or green options.

**The role of state-owned financial institutions:** State-owned financial institutions (SOFIs), such as the China Development Bank and ICBC, have been directed to fund major low-carbon projects. These institutions can have annual targets for green financing.

**International initiatives:** China's implementation externally includes greening the Belt and Road Initiative (BRI), whereby it has pledged no new coal plants financed abroad and is encouraging its banks to fund renewables in partner countries. Chinese institutions also participate in global funds (including contributing to the Green Climate Fund) and South-South cooperation on climate finance, reinforcing its financial diplomacy credentials.

### *India*

Key implementation steps for India's financial governance include the following:

**Priority sector lending:** Under PSL rules, Indian banks must ensure that a certain percentage of their lending goes to sectors of national priority (agriculture, MSMEs, etc.). In 2015, renewable energy was added with a target that each bank should lend up to a certain limit per borrower for renewables counting toward PSL. This has led banks to actively seek renewable energy projects to fund, boosting credit flow to clean energy. Implementation is monitored by the RBI through PSL compliance reports.

**Green deposit scheme:** Launched by the RBI in June 2023, banks and NBFCs can now offer 'green deposits' to customers. These work like normal deposits, but the money is earmarked for green projects. The RBI has provided a detailed framework, including eligible sectors (renewables, clean transport, sustainable water), an exclusion list (fossil fuel projects, nuclear, etc.), and requirements for third-party verification of use of funds. Banks are implementing this by designing green deposit products and advertising them to ESG-conscious investors. Over time, this could become a significant channel for retail and corporate money to flow into climate projects.

**Sovereign green bonds (SGrBs):** The government issued 160 billion rupees (around \$2 billion) in sovereign green bonds (SGrBs) in FY2022-23. The RBI, as the debt manager, auctioned these bonds successfully (with strong demand and slightly lower yields than regular bonds). The funds are being allocated to projects like solar, rail electrification, and so on. This implementation showed proof of concept and it is likely the government will continue annual green bond issuances, scaling up volume. It also encourages Indian companies and states to issue green bonds; several have, raising billions for renewable energy and urban transit. SEBI's role is to ensure these corporate green bonds meet guidelines (the SEBI green bond norms align with global Green Bond Principles).

**Climate risk and disclosure:** The RBI circulated a draft discussion paper in 2024 outlining guidelines for climate risk management and disclosure by banks.<sup>5</sup> While not finalised, banks have begun internal preparations, such as carrying out climate risk assessments and scenario analysis voluntarily. Some leading banks have issued ESG reports aligning with TCFD recommendations. SEBI, on its part, mandated the top 1,000 listed companies to provide Business Responsibility and Sustainability Reports (BRSRs), which include climate-related disclosures. This is being implemented now, giving investors more information to differentiate green from brown firms.

**Green finance instruments:** India is exploring currency risk-mitigation facilities for foreign investors in green projects (acknowledging that currency risk is a barrier for foreign debt in renewables). Also, new instruments like Infrastructure Investment Trusts (InvITs) for renewable energy help recycle capital. The government's climate strategy encourages such instruments and has given them tax advantages.

5 See <https://fidcindia.org.in/wp-content/uploads/2024/02/RBI-DRAFT-CLIMATE-RELATED-FINANCIAL-RISKS-28-02-24.pdf>

**Public financial management:** The Ministry of Finance is working to integrate climate considerations in public expenditure. For example, it has included climate priorities in the Finance Commission recommendations that guide how funds are shared with states. Some weight was given to forest cover (as a proxy for climate mitigation) in allocating funds to states. This creates a fiscal incentive for states to preserve forests (a step toward internalising environmental value in fiscal governance).

**Blended finance and development banks:** India set up the National Investment and Infrastructure Fund (NIIF), which has a mandate to invest in infrastructure including green infrastructure, often in partnership with foreign investors. Also, government-owned entities like the Indian Renewable Energy Development Agency (IREDA) provide concessional loans for renewables. These act as quasi-green banks. Expanding their capital and scope is an implementation measure to fill financing gaps.

**Insurance and pensions:** Regulators for insurance (IRDAI) and pensions (PFRDA) are beginning to think about green finance – for instance, allowing insurance companies to count green bonds as a separate category with potentially lower capital requirements. Such fine-tuning can drive institutional investors to allocate more to climate-friendly assets.

Overall, India's implementation aims to create multiple channels (banks, bonds, equity, external funding) oriented increasingly toward net-zero sectors, and ensuring the regulatory environment (RBI, SEBI, etc.) supports this shift.

## TAKEAWAYS FOR EMERGING MARKET POLICYMAKERS

As we underscored at the start of this chapter, when applying the three-pillar conceptual framework for governance of the net-zero transition, it is crucial to consider the unique characteristics of a country. Yet, at the same time it is important to recognise that climate change mitigation is a public good problem, with many shared benefits across states, municipalities, and the outside world. These factors influence the design, implementation, and success of policies and initiatives. Here we offer some policy recommendations based on the Chinese and Indian experiences:

- **Tailor governance to state capacity:** Countries should design net-zero strategies that fit their institutional capacity – a 'best fit' rather than a prescribed 'best practice'. If a country has strong planning institutions, it can set comprehensive plans and mandates at different levels of government and across sectors. If capacity is limited, it should focus on simpler, high-impact policies and leverage markets or external expertise (e.g., with targeted auctions and international partnerships). It will be critical to mobilise domestic resources by raising additional tax revenues and crowding-in institutional and private sector capital.

- **Strengthen coordination mechanisms:** Effective climate governance demands coordination across ministries (energy, transport, finance, etc.) and tiers of government. EMDEs should consider establishing high-level climate councils or task forces that convene key decision makers to align policies. For federal or decentralised nations, formal forums for central-local collaboration on climate are critical. Both China and India illustrate that siloed approaches will not work – China created a central Leading Group, and India is moving towards empowering climate planning and implementation. Whatever the governance framework, EMDEs should shape institutions or processes that break silos and sustain political attention on the net-zero agenda.
- **Integrated planning with development goals:** Net-zero plans should be integrated into national development strategies. EMDEs can embed climate targets in economic planning and link them with goals including energy security, job creation, and pollution control. Climate planning should be part of the development narrative. Planning should also be iterative – regularly updating targets as capacity and technology improve, as China has done by raising its ambition over time.
- **Leverage market mechanisms for efficiency:** Even where state-led action is dominant, market mechanisms improve cost-effectiveness and innovation. Carbon pricing, through either taxes or trading, sends economy-wide signals that encourage low-carbon choices. Setting up a full ETS or carbon tax may be challenging for some EMDEs, but they can start with pilot programmes or sector-specific trading schemes (like India's PAT) and expand gradually. Market-based auctions for renewables or concessions can also attract private investment and drive down costs – a key lesson from India's solar success. EMDEs should also identify and remove perverse incentives (e.g., fossil fuel subsidies) and consider redeploying those funds to support clean alternatives or to cushion vulnerable groups.
- **Mobilise finance through strong financial governance:** Aligning financial systems with climate goals unlocks capital. EMDE central banks and finance ministries can start by developing green finance taxonomies (defining what qualifies as climate-aligned investment) and mandating or encouraging disclosure of climate risks by financial institutions. Public finance should lead by example – issuing sovereign green bonds (as India did), budgeting for climate investments, and incentivising local green bond markets. Engaging domestic banks via priority lending guidelines or refinancing facilities for green projects can address the high cost of capital in EMDEs. At the same time, structuring projects to be 'investment-ready' for international climate finance (e.g., standardising PPAs for renewables, offering partial risk guarantees) is important for attracting foreign capital.

- **No single lever is sufficient:** A balanced approach is necessary. Solely relying on government planning without market feedback can lead to inefficiencies, while relying on markets without guidance can result in misalignment or social backlash. The triad of planning, markets, and finance should be pursued together; no single lever is enough. All levers, government and market-based, will need to be used to varying degrees. EMDE policymakers should identify the right mix: use planning to set direction and address coordination failures, markets to drive innovation and cost reduction, and financial governance to ensure money flows where it is needed and risks are managed.
- **Reform and involve state-owned enterprises:** Many EMDEs have significant SOEs in power, oil and gas, or industry. Reforming these to align with net zero (through performance metrics, governance changes, or partial privatisation) can yield big dividends. China's use of SOEs to champion renewables and EVs and India's plans to transition coal mining companies towards diversification are examples. EMDEs can direct SOEs to pilot new technologies (such as green hydrogen or carbon capture) that the private sector may shy away from initially. However, accountability and efficiency of SOEs must be improved to avoid wasteful investments.
- **Stakeholder engagement and a just transition:** Inclusive processes lead to more durable policies. Engaging stakeholders – subnational governments, businesses, workers, communities, youth – in devising and implementing climate strategies builds support and surfaces local knowledge. Planning for a just transition is crucial for EMDEs, where large populations depend on fossil fuel-related industries or are vulnerable to price increases. EMDEs should include social protection measures, like transition finance for affected communities, in their net-zero plans. This not only aids equity but also blunts political resistance.
- **International cooperation and platforms:** EMDEs often need external support in finance and technology. A clear takeaway is to be proactive in international climate diplomacy to secure support aligned with national plans. For instance, India's experience suggests establishing a country platform to coordinate donors and investors around its transition priorities. Such platforms can streamline project pipelines and match them with funding. Participating in mechanisms like the Green Climate Fund, using them in creative ways and forming coalitions (e.g., ISA for solar, or EV alliances), can amplify EMDE voices and facilitate knowledge transfer. South-South cooperation – sharing lessons among EMDEs – is also valuable, as peers often face similar constraints and can replicate successful approaches.

- **Capacity building is a continuous need:** Underlying all pillars is human and institutional capacity. EMDEs should invest in training officials (on climate policy, carbon markets, green finance), improving data systems (GHG inventories, climate risk assessments), and strengthening institutions (environment ministries, energy regulators, etc.). International agencies can assist with capacity building. Over time, improved capacity will allow more complex and ambitious policies to be deployed. In other words, start with what can be done now, but also create the conditions to do more later.
- **Monitor, learn, and adapt:** Both China and India have adjusted policies based on outcomes (for example, China tweaking its ETS, or India expanding PAT after success). EMDEs should set up robust monitoring and evaluation for their climate policies and be willing to iterate. Gathering data on emissions, economic impact, and co-benefits allows for course correction. This adaptive management approach is vital given the long timeline and uncertainties of the net-zero journey.

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# Climate change and India: An overview of the challenges and the policy response

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## 1 CLIMATE CHANGE: BACKGROUND

Since the beginning of the Industrial Revolution in the second half of the eighteenth century, industrial production has used fossil fuels. This releases CO<sub>2</sub>, one of the main greenhouse gases (GHGs) (along with methane), into the atmosphere. It is well understood that the accumulation of the stock of GHGs beyond a threshold level causes climate change.

Under the aegis of the United Nations Framework Convention on Climate Change (UNFCCC), there has been an attempt to coordinate the world's fight against climate change. The Kyoto Protocol in 1997 recognised that the poorer countries did not play a role in creating the climate problem (since their historical emissions were negligible compared to those of richer countries) and referred to “common but differentiated responsibilities”.<sup>2</sup> In other words, while every country needs to join in the fight against climate change, it is the industrialised countries that are required to do the bulk of the reduction in emissions – it was, after all, their ‘dirty’ industrialisation that caused the accumulation of the large stock of GHGs in the atmosphere. Under the current global agreement (signed in Paris in 2015), all countries are treated symmetrically and asked to submit the time paths for their (voluntary) carbon reduction plans (their nationally determined contributions, or NDCs). As an acknowledgement of the role of developed countries in causing the problem, these countries were asked (under the Copenhagen Agreement) to transfer an amount of US\$100 billion annually to developing countries. It was hoped that the NDCs would in the aggregate, over time, limit the rise in the Earth's temperature to 1.5°C above pre-industrial levels. At the 29th Conference of Parties (COP29) meeting in Baku in 2024, it was recognised that the path of world emissions was

1 I have received very helpful comments from Beatrice Weder di Mauro, Jeromin Zettelmeyer, Patrick Bolton, Catherine Wolfram and Estelle Cantillon. My greatest debt is to Jean Pisani-Ferry, who went through previous drafts with a fine-tooth comb and suggested changes, both of style and content.

2 Just before the Covid-19 pandemic, the US led in terms of cumulative emissions with 399 billion tonnes of CO<sub>2</sub> (25% of global emissions). Among the other countries/blocs, the EU28 accounted for 353 billion tonnes (22%), China 200 billion tonnes (12.7%), and India 48 billion tonnes (3%) (Our World in Data, 2017).

not consistent with the 1.5°C target set in Paris. Instead of peaking, emissions were rising continuously. Also, the promised transfer of \$100 billion from the richer countries to the poorer countries was inadequate – aside from the fact that this target was being missed regularly.

If the increase in the Earth's temperature is to be restricted to 1.5°C above pre-Industrial Revolution levels, then both speed of decarbonisation and finance are of the essence. The developed countries need to fund their own emissions reductions and also help finance the move to renewables in developing countries and the associated grid upgrades. Developing countries do not have the means to do this themselves; and it is worth repeating that they were not responsible for creating the climate problem. As Bolton and Kleinnijenhuis (2024)<sup>3</sup> argue, these transfers from developed countries to developing countries are more than just charity. Indeed, they are also in the interest of the developed countries, since the returns to 'investment' into preventing the global temperature from rising above the 1.5°C threshold are staggeringly large.<sup>4</sup> The authors suggest that these resource transfers would be a mix of public and private funds, and would consist of grants and other instruments.

However, the world is nowhere near to achieving this scenario of the developed countries helping the developing countries to achieve 'net zero'. What we have is a (mostly) non-cooperative interaction in the climate arena, with meagre (relative to requirements) flows from developed countries. The rich countries are loathe to provide funds in excess of their 0.7% of gross national income (GNI) for Official Development Assistance (ODA). Technology transfers are also not common. The poorer countries, hamstrung by a paucity of funds to fight climate change, allocate most of the funds for adaptation. As a result, mitigation is underfunded in these countries.

In this chapter, I explore these issues in the Indian context. India needs massive funds to decarbonise its power generation. Without these funds, the intermittency of renewables and the significant investment required for an overhaul of the grid are reasons to prolong the use of coal. Given India's economic size, its actions will affect the global fight against climate change.

At the same time, the European Union's proposed Carbon Border Adjustment Mechanism (CBAM) represents an example of non-cooperative behaviour. The European Union is aiming to reduce its carbon emissions by 55% relative to its 1990 levels by 2030. Since, in the goods covered by the CBAM, some imports come from countries where carbon prices are lower than in the European Union, it has decided to impose carbon tariffs to equalise the carbon cost across all suppliers – domestic and foreign. This is intended to prevent 'carbon leakage', i.e., moving production from the European Union, where the carbon price is higher, to jurisdictions where the carbon price is lower (or absent). This in turn

3 See Fabre et al. (2024) for a proposal to tax extreme wealth to fight climate change.

4 See their Figures 11 to 18, in which they deal with transfers from a variety of 'better-off' economies to developing economies. These include the United States not contributing to the transfer.

helps protect jobs in Europe, and in the fight against climate change this is laudable.<sup>5</sup> But it will penalise imports from developing countries, which do not have the cutting-edge technologies and, to repeat, did not cause the climate problem. The developed countries, it is alleged, have neither transferred financial resources nor given the poorer countries access to modern (clean) technology that uses renewable energy (this is discussed in Section 5).

The structure of the rest of the chapter is as follows. In Section 2, I look at the effects of climate change on the Indian economy, emphasising the effects on agriculture and highlighting the adaptation needs. In Section 3, I turn to mitigation of greenhouse gas emissions. Section 4 analyses India's commitments under the Paris Agreement and the need for a market to price carbon (Appendix 1 reproduces India's NDC commitment). Section 5 is a detour, analysing the position of India in the context of the CBAM (Box 1 provides some details on Indian steel exports to the EU). Section 6 deals with climate finance, while Section 7 provides concluding comments.

## 2 CLIMATE CHANGE IN INDIA: AGRICULTURE, HEAT, AND ADAPTATION

Climate change affects human activity and is also affected by it. Since the stock of GHGs is given at any point in time, and climate change today is a consequence of this, resources have to be found to cope with its (mainly negative) effects – i.e., for *adaptation*. But current economic activity contributes to (the flow) of emissions, which will add to the current stock GHGs, so resources must also be earmarked for reducing new emissions – i.e., for *mitigation*.

In analysing the effects of climate change on India, one must remember that it is a large country both in terms of physical size and population (it is, in fact, the world's most populous country). The situation is further complicated by India's state of economic underdevelopment, both in terms of its sectoral allocation of factors as well as the sheer number of people who barely eke out a living. To pull people out of poverty, the country needs to grow fast, and this requires large amounts of energy. Renewable energy is expensive, but if India were to use the energy source that is readily available – namely, coal – that would have serious implications for the world's fight against climate change. With an industrial sector characterised by antiquated technology and with limited budgetary resources, India's urgency to grow (out of mass poverty) will cause its emissions – and also, given its relative size, those of the whole world – to rise. The trade-offs here are stark.

At the same time, in terms of employment, India is dependent on agriculture. Thus, a large part of the country's efforts to address climate change must take the form of adaptation (and loss and damage).

5 Note when the EU wants to put a tariff on Chinese-built electric vehicles, there is no double-dividend (from the EU's point of view); auto sector jobs in the EU and reduced emissions are in opposition to each other.

The difficult choice India faces between financing adaptation and mitigation exists for all poor countries. Equity considerations demand recognition of the fact that these countries had very little to do with the stock of greenhouse gases in the atmosphere today – as mentioned above, the majority of past emissions were caused by the advanced countries' industrial development. Thus, both on account of their relative underdevelopment today and their negligible contribution to the stock of carbon in the atmosphere, they should be allowed some 'leeway' when it comes to asking for emissions reductions now – something that the Kyoto Protocol and the Copenhagen Agreement recognised.

Recent months have seen a recognition that the world's emissions are continuing to rise, when we need a decline if we are to meet the Paris Agreement's target of limiting the rise in the world temperature to 1.5°C. The withdrawal of the United States from the Paris Agreement and the failure to reach any consensus at the COP29 meeting in Baku on transfers from the rich to the poorer countries have heightened the pessimism. It is within this context, and given its relative size, that India is being asked to cut its emissions (its total emissions mean it is ranked third among the most-polluting countries). These developments have, possibly, caused the Indian government to articulate a position that economic growth should take precedence over additional allocations for mitigation policies, with China cited as an example of a country that grew rich before investing in renewables. In particular, the Indian government has hardened its position on phasing out coal<sup>6</sup> (India mined 1 billion tonnes of coal in 2024).

Having highlighted this position of the Indian government, in the rest of this chapter I look at the challenges facing India in the various sectors, and what the government can do about them.

Despite the giant strides made by India in industry and in its service sector, in many ways it remains an agrarian economy. Forty-six percent of India's labour force is employed in agriculture (although the sector accounts for only 15% of the country's GDP). Fifty-one percent of India's net sown area (71 million hectares) is rain-fed. Climate change makes the pattern of rainfall very erratic, and the impact on the timing, pattern, and intensity of the monsoon season rainfall (i.e., between June and September) is critical. It is not just the mean level of precipitation but also the variability over the harvest cycle that is affected by climate change. Various econometric studies show a marked decline in agricultural productivity for the country as a whole over time.<sup>7</sup>

6 That there is some thinking along these lines can be seen from the Economic Survey 2024-25 (Chapter 10) put out by the Finance Ministry and written under the supervision of the Government's Chief Economic Advisor (<https://www.pib.gov.in/PressReleasePage.aspx?PRID=2097921>).

7 Gupta (2022) summarises the effects on agriculture in detail. See Gupta et al. (2014), Jain et al. (2020) and Lo Palo et al. (2019) for details

India's mean temperature has risen by 0.63°C/100 years since records began in 1901. The maximum temperature has risen by 0.99°C/100 years over the same period. Heat-exposed work constitutes 50% of India's GDP, affecting 75% of its labour force. It is important to remember that about 30% of the world's poorest live in India, and hence the warming is potentially cataclysmic.

Under the Representative Concentration Pathways (RCP) 2.6 (Delink et al., 2019), for a 2.5°C rise by 2060, Indian GDP would fall by 4.5%, compared with 0.4% for the OECD and Europe.<sup>8</sup> There is uncertainty about equilibrium climate sensitivity, and if India's temperature rise is higher than its central estimate, the economic losses will be much greater.

Even for a small rise in global warming, the adaptation (and loss and damage) requirements will be huge. And unlike mitigation outlays, large amounts of private funding are unlikely to be forthcoming – in 2021-22, 98% of adaptation expenditure in India was met by domestic government funding (Chakravarty et al., 2024, p.15).

### 3 MITIGATION OF INDIA'S GHG EMISSIONS

#### 3.1 Methane

Methane constitutes about 15% of India's GHG emissions. Two of the major sources of this gas are enteric fermentation from cattle (India has a large cattle population that is difficult to justify in terms of its economic value) and paddy cultivation (rice is a major export crop for India).

The Global Methane Pledge, unveiled at COP26 in Glasgow in 2021, seeks to reduce global methane emissions by 30% between 2020 and 2030. It has been signed by over 150 countries, but not by India. In fact, agriculture does not feature as part of India's NDC.

#### 3.2 Carbon dioxide

India's energy needs are projected to grow at 8% annually. The share of power generation, industry, and transport in India's total CO<sub>2</sub> emissions are 53%, 25%, and 14%, respectively. Let us look at these in turn.

Power generation: India is not planning to phase out any thermal power stations until 2030; indeed, it is adding more. India generates 71.2% of its electricity from thermal plants (accounting for 94.9% of power sector emissions), and analysts have pointed out that this is inconsistent with a 1.5°C increase.<sup>9</sup> We need its share to decline to under

<sup>8</sup> For a lower given rise in global temperature, the losses across regions are more similar.

<sup>9</sup> See Figure 20 in Bolton and Kleinnijenhuis (2024).

20% by 2030, and to zero by 2035.<sup>10</sup> According to a March 2025 article in *The Guardian*, India's state-owned company, Coal India, was responsible for emitting 1,548 tonnes equivalent of CO<sub>2</sub> in 2023. This put it in second place among the top-emitting fossil fuel companies.<sup>11</sup>

The problems of India's electricity distribution companies are well-known. These are loss-making companies, and mostly publicly owned. As the economy grows, electricity demand grows with it. Electricity is sold at low prices (and sometimes given free to farmers). Renewable energy requires up-front investment. Greater reliance on renewable energy would typically favour the decentralisation of electricity generation compared to a coal-based system, in which generation is generally located near coal mines. In India, however, the transition implies a major geographical shift in electricity generation towards the western and southern regions of the country, where solar and wind potential is high. Surplus electricity from these regions will need to be transmitted to other regions, necessitating new high-power interstate transmission lines. With renewables there is also the problem of intermittency, requiring investment in storage (and possibly hydroelectric and atomic power). Total reform of this sector is required, including the demand side.

In India, most power plants are 'young' (i.e., recently constructed) or in the pipeline. New thermal power plants, with lives of up to 40 years, are under construction. Could renewable prices fall quickly enough to phase these out more quickly?

Good progress has been made in bringing renewable sources online, with the total solar and wind capacity expanding from about 4.5 gigawatts (GW) in 2005 to just under 134 GW in 2023. By comparison, however, China's performance was much stronger, with a six-fold increase in capacity to 793 GW. In fact, China added close to 300 GW of solar and wind capacity in 2023 alone!<sup>12</sup> In terms of share, renewables (excluding large hydro) accounted for 13% in India's electricity mix in 2023, compared to 18.2% in China.

But despite the truly spectacular increase in renewable power in China, the country continues to rely on thermal power. In 2024, China approved 66.7 GW of new coal-fired plants and started construction on 94.5 GW of new coal power projects.<sup>13</sup> The bringing online of these coal-based projects as caused concern over China's decarbonisation goals. At the same time, President Trump has approved more mining of coal and drilling for oil in the US. The move towards less-polluting fuels certainly seems to be on the backfoot.

10 The power demand during the hot summer of 2024 was met by ramping up existing coal-fired power supply. The coal was obtained from imported sources.

11 "Half of world's CO<sub>2</sub> emissions come from 36 fossil fuel firms, study shows", *The Guardian*, 5 March (<https://www.theguardian.com/environment/2025/mar/05/half-of-worlds-co2-emissions-come-from-36-fossil-fuel-firms-study-shows>).

12 "China's solar, wind power installations soared to record in 2024", Reuters, 21 January 2025.

13 "China's coal power habit undercuts 'unprecedented pace' of clean energy", *The Guardian*, 13 February 2025 (<https://www.theguardian.com/world/2025/feb/13/china-coal-power-energy-production-quotas>).

Turning to industry, I first note that Indian industry, like so much in India, is ‘bimodal’ – there are modern large firms and a micro, small, and medium-sized enterprise (MSME) sector. The MSME sector accounts for 30% of India’s GDP, 40% of its exports, and around 25% of its heavy industry energy consumption. This sector has been hit by adverse shocks including the introduction of the Goods and Services Tax (GST), the demonetisation exercise, and the Covid-19 pandemic. It requires a large infusion of capital to stay afloat, even before addressing decarbonisation. I discuss this in Box 1 in the context of India’s steel industry.

With regards to transport, public transport, rather than the use of private vehicles, should be encouraged. Electrification of the railway system, with power from renewables, is a priority. Short-haul flights also need to be discouraged. Between haulage by road or railway, the latter should be preferred. It is worth noting that over the last few decades, India’s transport infrastructure has come to resemble that of North America, as opposed to, say, Europe. This needs to be reversed as more electricity is generated from renewable sources.

#### 4 INDIA’S NDC COMMITMENTS AND A CARBON MARKET

The main elements of India’s COP26 NDC are as follows.<sup>14</sup> First, in the Paris 2015 NDC, the emissions intensity of GDP was to be reduced by 33–35%, compared to the 2005 level. The COP26 NDC raised this target to 45%. Second, the share of non-fossil fuel-based electricity generation capacity in 2030 was pegged at 40%; this is now raised to 50% of total capacity, or 500 GW. Both targets could be met easily. Finally, the 2015 afforestation target of creating an additional 2.5 to 3 Gt-CO<sub>2</sub> equivalent forest sink by 2030 in unchanged.

As is obvious from a cursory look at India’s Paris commitments, most of the decarbonisation promises are in terms of carbon intensities of output, and not absolute caps. For a growing economy, it is important to know whether the scale of output may swamp the decline in carbon intensity. The only concrete hint in this regard is that India has promised to achieve the net zero target by 2070. A carbon market that sets the price of carbon relative to the level of permitted emissions is essential to guide policymakers towards such a target.

Separately from this, the European Union’s CBAM proposal seeks to put a carbon ‘tariff’ on imports that have not paid a carbon price equal to that prevailing in the Union. If implemented, in the absence of a carbon price in the exporter’s market, the European Union will collect a tax that would have accrued to the exporting country, had there been a carbon price there.

14 Reproduced as Appendix 1.

Thus, the need for a carbon market assumes some urgency, both to translate the carbon intensities to a level of emissions – via a carbon tax or an emissions trading system (ETS) – and/or to keep some of the tax that would otherwise go into the EU coffers in the event of the CBAM’s implementation.

The Government of India introduced the Energy Conservation Act in December of 2022, which seeks to introduce a carbon credit trading scheme (CCTS). Ahluwalia and Patel (2023) outline a strategy for the proposed ETS for India, based on international experience:

*“... the ETS should have the following features: (i) Each producing unit should be allocated emissions allowances based on output. This could be set initially at the industry average of the previous year. Units exceeding their allowance would need to buy credits from under-emitting units across all industries covered, creating a unified market-priced carbon credit system. The regulators can also set floor and ceiling prices of the credits to ameliorate price uncertainty issues and create confidence in the system. (ii) Emission allowances for different sectors will need to be steadily reduced over time consistent with national decarbonisation targets. This is crucial for the country to progress towards net zero emissions. (iii) Allowances could be distributed for free in the initial years, followed by an increasing proportion being auctioned over time. Auctioning would generate revenue for the government which could be used for climate-related expenditure, thus providing some of the revenue advantages of a tax. Administering the ETS will require a high-quality regulatory system to determine (i) the initial allocation of allowances across industries and (ii) to calibrate the pace of emission reduction in each industry” (p. 359).*

One point that is worth noting is that, as it currently stands, electricity generation will not be within the ambit of the ETS. This makes very little economic sense. Upstream activities should decarbonise, benefiting all the downstream production activities with varying degrees of difficulty in abatement.

While we wait for the establishment of a carbon market in India, it is important to remember that there are fairly high fuel excise taxes (mainly to provide a steady source of revenue for the government) that act as implicit carbon taxes. The OECD estimated the coverage of these taxes to be 53.9% of all emissions in 2023, while 2.5% of emissions are subsidised. This translates into a net effective carbon rate of €7.23 per tonne of CO<sub>2</sub>.

## 5 THE EU CARBON BORDER ADJUSTMENT MECHANISM AND INDIA

The Carbon Border Adjustment Mechanism is intended to help the European Union to reduce its carbon emissions by 55% by 2030 (relative to 1990 levels). Imports account for about 20% of the Union's carbon emissions. The CBAM proposal seeks to address the issue of possible carbon leakage, i.e., the relocation of production of carbon-intensive traded goods to jurisdictions where the price of carbon is lower. The mechanism will initially apply to six sectors (considered most susceptible to carbon leakage): cement, aluminium, fertilizer and chemicals, electricity, and iron and steel.

The CBAM proposals will be formally implemented on 1 January 2026 and will require importers in the European Union to make financial adjustments based on the carbon emissions embedded in imported goods. The tax collected from the CBAM will go towards the EU general budget. With its implementation, free allowances under the EU ETS will be phased out.

The implementation of the CBAM presents significant administrative and technical challenges for Indian producers. The reporting obligation (effective from October 2023) mandates the disclosure of the quantity of imported goods, their embedded carbon emissions, and any applicable carbon costs incurred in the exporting country. This requirement poses significant challenge for Indian exporters, which must conform to EU standards by monitoring, calculating, reporting, and verifying emissions. Smaller Indian firms may find this a daunting task. The CBAM framework has also established a mechanism for determining the carbon footprint of imported goods in instances where precise embedded emissions data are unavailable. In such a scenario, default values will be utilised. India's inadequate data infrastructure for emissions collection may necessitate default emission data usage.

India's exports of aluminium and of iron and steel are expected to be significantly affected by the CBAM, as the European Union is a major market for these commodities. The European Union receives 16% of India's merchandise exports. India's exports (to all destinations worldwide) were \$22 billion in 2022-23, 28% of which was goods going to the EU and covered by the CBAM. In 2022-23, iron and steel exports to the European Union were worth \$4 billion and aluminium exports were worth \$2 billion. For both commodities, the average carbon intensities are three times those in the European Union.<sup>15</sup> Indian industry uses coal-fired electricity, which makes it carbon-intensive. The price of carbon is currently €70-75 per tonne of CO<sub>2</sub> in the EU ETS, whereas in India it is considerably lower (€7.23 per tonne, if fuel taxes are included). This differential will not disappear even if India's carbon market is set up. After all, China's carbon price is at \$5 per tonne, Korea's is \$8 per tonne, and Indonesia's \$1 per tonne. And the carbon markets in these countries, unlike India's proposed carbon market, include the power sector.

15 See Majumdar et al. (2024) on the CBAM's effects on India and other trading partners of the EU.

The Indian government has been vocal in its opposition to the CBAM, pointing out that it constitutes a unilateral trade restriction, and one that requires a lot of paperwork. In short, it represents a substantial non-tariff trade barrier, applied unilaterally.<sup>16</sup> This view is shared by other exporting countries to the European Union, including China.<sup>17</sup>

India's case against the CBAM has some justification. If it goes through in its present form, there would be pressure on Indian exporters to the European Union to conform to its emissions standards. This is an example of the 'Brussels Effect', whereby the European Union is able to 'force' other countries to raise their emissions standards in line with its own. The exporting countries have to find the resources for this upgrading of standards. Having said this, the Indian government is also hedging its bets – it is also considering a green industrial policy to decarbonise its production, at least for the EU market.

#### BOX 1 THE STEEL SECTOR IN INDIA: SOME DETAILS<sup>18</sup>

Modern steel making began in India with the establishment of the Tata Iron and Steel Company (TISCO) in 1907. Today, the industry is dominated by firms that entered in the 1970s and the 1980s. The total employment in the industry in 2021 was 47,000 workers. The steel sector accounts for about 2% of India's GDP. Given that industry's total share in GDP is under 15%, steel is an important sector. It is also one of the leading export sectors of India; and the EU is a prime destination of the country's steel exports. Moreover, India currently is second only to China in steel production. By 2050, it is estimated India will produce nearly a fifth of the world's steel output (IEA, 2020).

The International Energy Agency (IEA) estimates that to meet the Paris Agreement targets, emissions from the steel sector must decline by at least 50% by 2050, and from there on continued decline to reach the net zero.

Together with India's promise to reach net zero by 2070, the Ministry of Steel has set its own targets for emissions reductions in the sector by 20% by 2030; by 50% by 2047; and net zero by 2070.

In addition to the big companies running integrated steel plants (ISP), which produce 'primary steel' using a blast furnace-basic oxygen furnace (BF-BOF), a secondary steel sector is dominated by the small and medium-sized enterprises (SMEs). These use either a direct reduced iron-electric arc furnace (DRI-EAF) or a DRI-induction furnace (DRI/IF). The primary steel producers (i.e., those using BF-BOF) account for 46% of crude steel production, while the EAF and IF producers account for 23% and 31%, respectively.<sup>19</sup>

16 The Indian Finance Minister, Nirmala Sitharaman, has said this will be challenged at the WTO.

17 India and China both tried to raise the issue of CBAM at the COP29 meeting in Baku.

18 See Das and Bandyopadhyay (2025) and Elango et al. (2023) for more details.

19 See Section 4 of Das and Bandyopadhyay (2025) for details.

**BOX 1 (CONTD.)**

The emissions intensity of steel production in India is around 2.54 tCO<sub>2</sub>/tcs, which is far higher than the global average. The emissions intensity of the BF-BOF production is nearly 3.0 tCO<sub>2</sub>/tcs, which is also far higher than the global average of around 2.0 tCO<sub>2</sub>/tcs. For the EAF plants, it is 1.5 tCO<sub>2</sub>/tcs, which is much higher than the global firms in this category (Ministry of Steel, 2024). Since the demand for steel in India is predicted to increase by around 87% between 2021 and 2030, decarbonisation is essential.

It is projected that the burden of CBAM implementation will be unevenly distributed across regions, with China, Russia and India the most affected.

Finally, it is worth noting that according to the World Bank's relative CBAM exposure index for steel, India is the third most-exposed country, after Zimbabwe and Ukraine.

The case of the iron and steel sector is important in terms of the role of SMEs and the financial and technical constraints they face in decarbonisation, and indeed to stay afloat. It also highlights the additional challenges and the urgency that CBAM introduces.

**6 CLIMATE FINANCE**

According to the Indian government's estimates, meeting its climate pledge will require \$1.05 trillion (or \$170 billion annually) by 2030.<sup>20</sup> Bolton and Kleinnijenhuis (2024) put a figure of \$1.14 trillion (for 2025–2035) on decarbonising the power sector.<sup>21</sup>

Actual *mitigation* finance flows to India were \$50 billion in 2020–21, an increase of 20% over 2019–20 levels. Domestic finance accounted for 83% of the total (66% as from private sources, and the rest public), and 17% from foreign sources (of this, 37% came from official sources, including overseas development aid) (Chakravarty et al., 2024, p 15). Of the total flows to mitigation, 47% went towards clean energy, 35% towards energy efficiency, and 18% towards clean transport.

*Adaptation* expenditure reached \$15 billion in 2021–22, a three-fold increase since 2019–20 (but this could be due to new heads being added). Of this, 98% came from the central and state governments (ibid., p. 28). The primary outlays are on disaster risk management (42%) and flood and cyclones (32%). Of course, some outlays under these heads had been made even before they were listed as “adaptation to climate change”.

20 Chakravarty et al. (2024) p 15. The IEA (2023) puts it at \$160 billion per annum for net zero 2070. Bloomberg NEF (2023) puts the requirement at \$192 billion for net zero 2050 (Tilotia and Vardhan 2024). See also Singh and Sidhu (2021).

21 Since no action is taking place, and the carbon budget is shrinking, these estimates will turn out to be lower than what is required.

Given the local nature of adaptation, the state governments in India are primarily responsible for these expenditures. The Climate Policy Initiative report puts the collective annual investment needs of six states alone at \$5.5 billion from 2021 to 2030 (Chakravarty et al., 2024, p.32). This is well beyond the financing capabilities of the states, which also face borrowing constraints under new fiscal rules and pressure to reduce existing debt burdens.

Further, it is essential to understand the avenues for investment in the hard-to-abate sectors. In this context, transition finance, which refers to financing projects that are not entirely green but are progressing towards reducing emissions, is becoming increasingly relevant. Hard-to-abate industries such as steel and cement manufacturing face significant challenges in emissions reductions. These challenges include high capital expenditures, the long lifespan of installed high-emissions assets, and the lack of technological maturity and high costs of newer net-zero technologies, which make these technologies commercially unattractive. However, there are mature, commercially viable technological solutions that can help reduce emissions significantly, albeit not reduce them to near zero. As these technological solutions cannot be classified as 'green', their access to capital is often limited. Transition finance – that is, not 'green' – can help reduce the burden of these high-emitting units.

While the growth of climate finance flows has been quite good, they constitute less than a third of the requirement. It has been suggested that market-based incentives need to be supported and augmented by development banks and financial intermediaries. But above all, standardisation and mandating disclosures have to be pushed.<sup>22</sup> It is worth noting here that India's track record on gathering environmental data and taking hard decisions based on these data leaves a lot to be desired.<sup>23</sup>

## 7 CONCLUSIONS

India is a large economy, with a large proportion of the workforce engaged in agriculture that is primarily rain-fed. Climate change is affecting this sector in a major way. This calls for significant adaptation (and loss and damage) expenditures.

Turning to mitigation, India has made significant progress in installing renewable energy capacity. According to most researchers, however, it is not shaking off its reliance on coal fast enough to be consistent with net zero in 2070. There are political economy reasons for this (for example, there are poor provinces in India where coal mining is a major employer). Also, large expenses have to be incurred on batteries and grids for renewables. But the phasing out of coal is something that is unavoidable in the fight against climate

22 See Chakravarty et al. (2024) and Ahluwalia and Desai (2024) for further discussion.

23 Delhi has been declared the most polluted capital city in the world for the sixth year running. Of course, this relates to local pollutants, not climate change, but it does not inspire confidence in the government's ability to deliver! According to The Guardian, India's coal-fired power plants are equipped to trap 5% of the pollutants generated, whereas China traps 95% (<https://www.theguardian.com/environment/2024/apr/19/clean-up-indian-coal-fired-power-plants-could-saved-lives>).

change and meeting India's net zero target. Commissioning new thermal plants gives the wrong signal, as these lock the country into coal for decades. India's emissions represent a not insignificant contribution to the world's aggregate emissions, and in this endeavour the transfer of funds and technology from richer countries is essential. As mentioned above, this is not just a matter of charity or historical responsibility, it also makes economic sense for the developed countries. So far, these flows have not been forthcoming in significant quantities relative to the needs.

There is also a lack of clarity on the path India will take to achieve its net zero target. It continues to set its targets in terms of emission intensities. For a growing economy such as India, the scale of power demand could outweigh the improvements in emissions intensities. The presence of a carbon price would give an indication of the level of total emissions, and an indication of the path to the 2070 target. As things stand, however, even if a carbon price is implemented, insurmountable problems will remain, since the power sector is currently not included in calculating the price of carbon.

To sum up, India needs to grow in order to pull its citizens out of mass poverty. Its carbon footprint is high in aggregate (though not per capita) terms. Thus, decarbonisation in the country is as important from the world's point of view as from India's. But the process of decarbonisation is expensive – green jobs are not free. In a relatively poor country, two equally important targets – growth to reduce poverty and decarbonisation – are jostling for very limited resources. Transfers from developed countries could help solve this dilemma by fostering green growth. The track record of climate finance has not been encouraging. The Trump presidency, with its rhetoric encouraging new oil and coal explorations, further vitiates the atmosphere.

Finally, let me sum up the salient points of my chapter here.

1. Because it is a large economy and one particularly exposed to the consequences of global warming, India has a vested interest in contributing to limiting of the rise in global temperature. It must act to limit, and eventually reduce, its GHG emissions.
2. There is, however, a tension between climate action and development policy. India must find a growth-friendly compromise between two potentially conflicting objectives. The current reliance on coal epitomises this tension. India would be better off if it were able to substitute away from coal, but for the time being coal-fired power plants remain the cheapest way to produce electricity.
3. India cannot afford the investments required to reconcile development and decarbonisation on its own. Moreover, adaptation costs are growing and already exceed the states' financing capacities. The Global North should help India to finance mitigation and adaptation costs by providing \$190 billion annually (\$170 billion for mitigation and about \$20 billion for adaptation per year) in the next ten years.

4. The decision by the government to establish a carbon credits trading scheme (CCTS) is a major step in the right direction. Currently, however, the power sector is not subject to the planned ETS. This makes very little economic sense. Without the power sector in the ETS, the price signal of the scheme is diluted considerably.
5. The European CBAM is being opposed by the Indian government on the grounds that it serves protectionist purposes. This critique has some justification. India and the EU should find ways to compromise over the implementation of the CBAM – for example, by rebating the revenue collected from the mechanism in exchange for lower-emission technologies.

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## APPENDIX: INDIA'S UPDATED FIRST NATIONALLY DETERMINED CONTRIBUTION UNDER PARIS AGREEMENT (2021-2030)

### August 2022 Submission to UNFCCC

#### INDIA'S UPDATED FIRST NATIONALLY DETERMINED CONTRIBUTION WORKING TOWARDS CLIMATE JUSTICE

Pursuant to decision 1/CP.20, India submitted its Intended Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) on 2nd October, 2015. In accordance with decision 1/CP.21, paragraph 22, India's Intended NDC is now its first NDC under the Paris Agreement.

The Article 4, paragraph 9 of the Paris Agreement provides that each Party shall communicate a nationally determined contribution every five years in accordance with decision 1/CP.21. Decision 1/CP.21, paragraphs 23 and 24, requests Parties to communicate or update this contribution and to do so every five years, pursuant to Article 4, paragraph 9, of the Agreement.

Therefore, in accordance with the aforesaid provision of the Paris Agreement read with relevant decisions, India hereby communicates an update to its first NDC submitted earlier on October 2, 2015, for the period up to 2030, as under:

India's NDC is ambitious, and it is a significant contribution towards achieving the goals of the Paris Agreement. Environmentally sustainable, low carbon initiatives are underpinning all key sectors of the Indian economy.

India reaffirms its commitment to the UNFCCC and the Paris Agreement on Climate Change.

This update to India's existing NDC is a step forward towards our long term goal of reaching net-zero by 2070.

No change in the other sections or text or otherwise of the document containing existing first NDC is proposed at this stage. India reserves the right to provide further updates by way of additional submissions on its NDC, as and when required.

1. To put forward and further propagate a **healthy and sustainable way of living** based on **traditions and values of conservation and moderation**, including through a **mass movement for 'LIFE'- 'Lifestyle for Environment'** as a key to combating climate change [UPDATED].
2. To adopt a **climate friendly and a cleaner path** than the one followed hitherto by others at corresponding level of economic development.
3. To reduce **Emissions Intensity of its GDP by 45 percent by 2030**, from 2005 level [UPDATED].
4. To achieve about **50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030**, with the help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF) [UPDATED].
5. To create an additional carbon sink of 2.5 to 3 billion tonnes of CO<sub>2</sub> equivalent through additional forest and tree cover by 2030.
6. To **better adapt** to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
7. To mobilize **domestic and new & additional funds** from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
8. To **build capacities**, create domestic framework and international architecture for quick diffusion of cutting-edge climate technology in India and for joint collaborative R&D for such future technologies.



# Climate finance for Africa: The opportunity for resilience and growth

**Vera Songwe**

*Liquidity and Sustainability Facility and the Brookings Institution*

How Africa responds to the interlinked challenges of nature degradation, climate change, and biodiversity loss over the next decade will not only shape its development trajectory but also influence how the continent engages with the rest of the world. Two factors will be especially critical: the availability of long-term affordable financing, and the effectiveness of domestic and international institutions responsible for managing the transition towards a more sustainable and prosperous future.

Climate finance stands to play a pivotal role in enabling African countries to adequately respond to the threats to growth and prosperity posed by climate change. Over the past five years, the continent has been confronted with overlapping crises, including the COVID-19 pandemic, supply chain shortages, inflation, rising interest rates, rising debt service, and, more recently, trade tensions. These crises have severely constrained Africa's capacity to effectively mobilise and allocate resources for development and climate.

The nature and climate crises add an even more existential layer to this challenge. Countries are learning to navigate complex pathways to mobilise, allocate, and deploy finances effectively for resilience and mitigation, while working with a wide array of external partners and domestic constituents. Increasingly, African countries acknowledge that the climate transition, if well executed and accompanied by adequate resources, will deliver economic transformation and improve living standards on the continent. Simply put, climate finance is development finance.

At the same time, the institutions required to support the transition and build a transformed continent lack the right skill sets to do so. Global leadership on the topic is wavering and many institutions are unclear about their mandates on climate. Low- and middle-income countries themselves are struggling to put the climate debate on the agenda while confronted with issues of debt, low infrastructure development, and unemployment. While there is agreement that climate change must be an all of government agenda, many countries do not have the institutional capacity to build robust, interconnected, and interdependent policies. In places where this capacity does exist, progress on the climate agenda is accelerating.

## THE COST OF CLIMATE CHANGE

The world is dangerously off target to achieve the Paris goals. Atmospheric concentrations of greenhouse gases continue to rise.<sup>1</sup> Global levels of CO<sub>2</sub> and methane reached new highs in 2021, while the increase in CO<sub>2</sub> from 2020 to 2021 exceeded the average annual growth rate of the previous decade and the annual rise in methane was the largest ever recorded. The year 2022 was either the fifth or the sixth warmest year on record, depending on the data set (WMO, 2023b).

These rising emissions are translating into record-breaking temperatures. Each of the past ten years (2015–2024) has been the warmest on record (WMO, 2025). In 2024, the global average near-surface temperature was 1.55 °C ± 0.13 °C above the 1850–1900 average, making it the hottest year in the 175-year observational record. Each year, the destruction to the planet intensifies. While the overall situation is worsening globally, over the past 60 years Africa has recorded a warming trend that has generally been more rapid than the global average according to the Intergovernmental Panel on Climate Change (IPCC).

Developing countries, and Africa in particular, stand to lose the most if this trend continues. Each episode of extreme weather results in development losses, particularly in low-income countries. Rising temperatures translate into acute social and physical hardships for populations, including the destruction of critical infrastructure, homes, forests, and biodiversity. They also threaten the stability of institutions such as the financial system and the health system. According to the Integrated Food Security Phase Classification (IPC), by mid-2024, the compounded effects of multiple shocks – including intensifying conflict, drought, and high domestic food prices – had led to worsening food crises in 18 countries across the world (IPC, 2024). In eight countries, at least one million more people faced acute food insecurity in 2024 compared to 2023<sup>2</sup>. The year 2024 also saw the highest number of new displacements – people leaving their homes for the first time in search of food – recorded in a year since 2008. Improvements in livelihoods are also deeply correlated with climate events and policies.

Recent climate events in Africa underscore the continent's particular vulnerability. The 2024 monsoon season was accompanied by an abnormally high rainfall, leading to flooding across the Sahel that inundated significant cropland (FAO, 2024) and caused widespread loss of life. In East Africa, spring floods (OCHA, 2024a)<sup>3</sup> led to major casualties and displacement in countries including Kenya (OCHA, 2024b) and Tanzania, also destroying croplands and resulting in loss of livestock. Lake Victoria reached record-high levels, causing downstream flooding that severely affected South Sudan later in the year. In contrast, dry conditions during what is usually the wet season in late

1 The latest year for which consolidated global figures are available.

2 <https://www.ipcinfo.org/ipcinfo-website/resources/resources-details/es/c/1157145/>

3 See also <https://www.unhcr.org/news/stories/five-things-know-about-catastrophic-flooding-east-and-horn-africa>

2023 and early 2024 resulted in significant drought in north-western Africa and many parts of interior Southern Africa (UNHCR, 2024a) – in particular, in Zimbabwe, Zambia (UNHCR, 2024b), Botswana, and Namibia. The severe drought had significant impacts on agriculture and hydroelectric production.

The financial cost of the nature and climate events in Africa is staggering. It is estimated that African countries will lose close to \$90 billion, or about 4% of the continent's GDP, yearly as a result of loss and damage suffered, and an additional 5–10% of GDP will need to be spent on building back. The loss and damage costs in Africa due to climate change are projected to reach US\$290 billion under a 2°C warming scenario (WMO, 2023a).

A warming climate is also undermining Africa's ability to provide the world with some of the resources needed for global prosperity, such as critical plant species. Africa's Great Rift Valley, for example, is the source of many rivers and streams in the region. The region is also home to the African Great Lakes, which hold over 25% of the world's unfrozen freshwater and more than 90% of Africa's total freshwater.

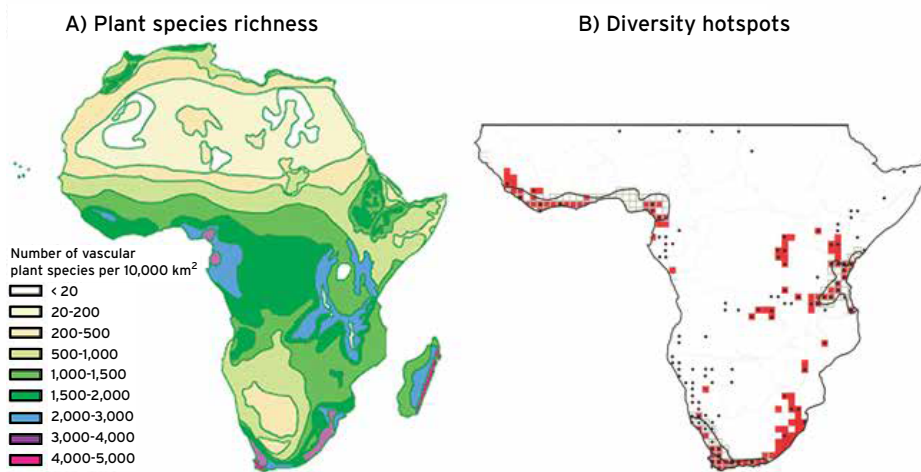
Biodiversity loss in Africa is accelerating due to the rapid environmental change, in a context where natural resources are a mainstay of livelihoods and a cornerstone of socioeconomic development for a young and growing population. Africa accounts for around 25% of global biodiversity, distributed across various ecosystems.<sup>4</sup> It is home to eight of the world's 36 recognised biodiversity hot spots, which together host approximately one-quarter of the world's mammals and birds. Climate change impacts are expected to affect biodiversity in the Congo Basin,<sup>5</sup> the world's second-largest rainforest which is home to a number of endemic species unmatched around the world (Achieng et al., 2023). The Basin supports over 400 species of mammals, 1,000 species of birds and 700 species of fish.

Responding to the climate crisis in Africa calls for a three-pronged approach: mitigation, resilience, and nature preservation. Notwithstanding its low emissions levels and favourable initial endowments, Africa must engage on all three fronts. With the continent's trends of increasing population, urbanisation, and industrialisation, emissions are set to increase in the medium term, but they can be managed and steered towards a progressive transition which delivers growth while protecting the planet (Songwe, 2024).

4 <https://globalhumane.africa/2024/07/19/biomes-and-biodiversity/>

5 The six Congo Basin countries are Cameroon, the Central African Republic, the Democratic Republic of Congo, the Republic of Congo, Equatorial Guinea, and Gabon.

FIGURE 1 AFRICA'S RICH BIODIVERSITY UNDER THREAT



Note: Diversity of the Diversity of the African flora, biodiversity hotspots and need for conservation and in some cases more collecting activity and exploration (compare with Fig. 6 and 8). (A) Map showing estimated number of vascular plant species per 10,000 km<sup>2</sup> in sub-Saharan Africa. (B) Sub-Saharan areas estimated to be of high conservation value. The diversity hotspot areas defined by Myers et al. (2000) are indicated by solid black lines. Open cells surrounded by grey lines are one-degree squares covered by the hotspots of Myers et al., while the redefined hotspots by Küper et al. (2004) are indicated with red cells. The map also shows (black dots) the 125 cells of the 'near-minimum-cost'-set where the most species can be protected at lowest cost. (A) Part of map of estimated plant diversity of the world by Mutke and Barthlott (2005). (B) From Küper et al. (2004).

Source: Demissew et al. (2017).

## AFRICA'S CLIMATE MITIGATION AGENDA

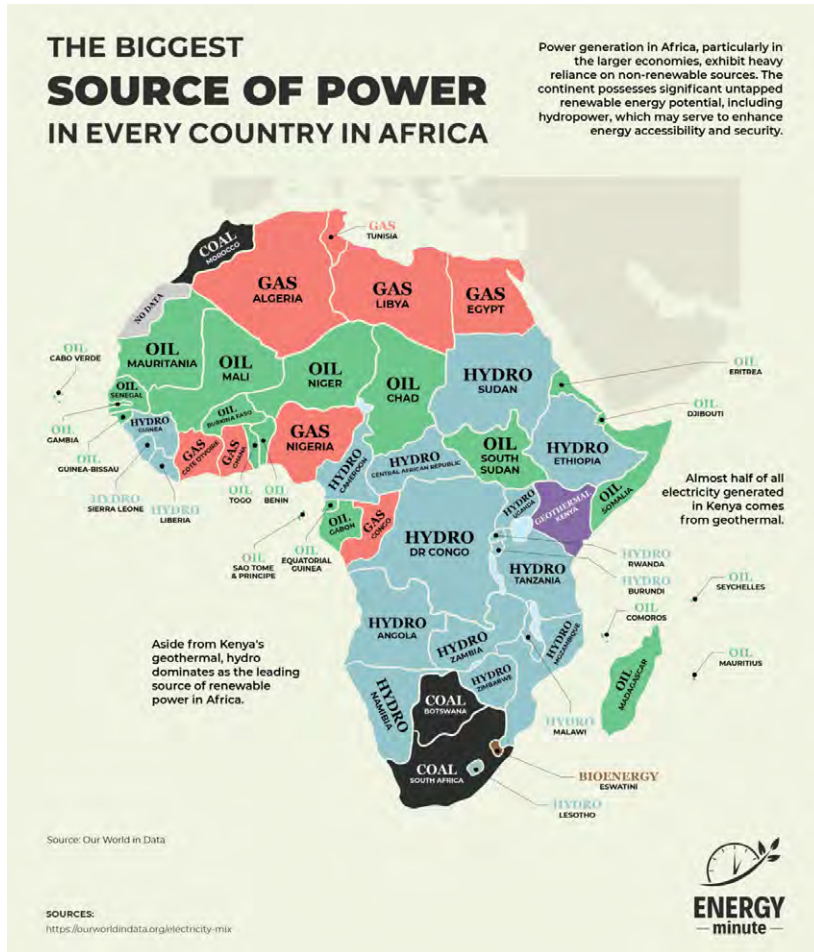
Africa is responsible for only 4% of global greenhouse gases, largely due to its very low energy consumption levels. However, the continent faces a paradox: it is poor in terms of energy access, despite being rich in renewable energy. Currently, a substantial share of its energy – in North and Southern Africa in particular – comes from coal and other fossil fuels. In contrast, in West and Central Africa hydroelectricity is dominant, while geothermal is prevalent in East and Central Africa.

Of the 1.2 gigatons (Gt) of carbon dioxide emitted in Africa in 2020, 40% came from fossil fuel-based electricity and heat generation, a quarter from transport, and another 17% from other productive uses. Over 600 million people on the continent lack access to electricity, and with rapid urbanisation and increases in incomes, energy demand from those who already have access is set to increase further. Closing the energy access gap will require an estimated annual investment of over \$25 billion up to 2030.

As a result, strategies to promote renewable energy and, where appropriate, the use of transition fuels such as gas are important for the continent. In West Africa, for example, gas – which is in abundant supply in Senegal and Mauritania – can and should be used as a transition fuel while scaling up clean energy alternatives. Egypt, with its Benban

Solar Park (one of the largest in the world),<sup>6</sup> has demonstrated that it could sustainably transition to more renewable energy use. In many African countries, off-grid energy systems, distributed renewable energy, and minigrids (localised power systems used in many rural areas) all form part of the solution. In Nigeria, for example, a number of minigrid projects are being launched by the government to replace diesel fuel. Waste-to-energy initiatives, such as those being deployed in Kenya, are also gaining traction to address the growing challenge of waste management.

FIGURE 2 MAIN SOURCES OF POWER IN AFRICA



Source: [https://www.reddit.com/r/Africa/comments/li3g9qd/the\\_biggest\\_source\\_of\\_power\\_in\\_every\\_country\\_in/](https://www.reddit.com/r/Africa/comments/li3g9qd/the_biggest_source_of_power_in_every_country_in/)

6 <https://www.afdb.org/en/success-stories/egypt-benban-model-clean-energy-production-africa-60169>

Africa's mitigation pathway is unique as it seeks to increase growth and the prosperity of its citizens in an equitable way while also protecting the environment. Reducing emissions is not enough. Given the accelerating impacts of climate change, countries must also build resilience and protect biodiversity. With the right investment incentives and technology-sharing agreements, both of which are currently lacking, Africa could play a key role in greening the hard-to-abate sectors such as steel, phosphate, and others.

## CLIMATE ADAPTATION IN AFRICA

Africa is already bearing the brunt of climate change, and it must build resilient infrastructure and modify existing practices to alleviate the current and future impacts. Adaptation challenges are daunting, largely because – unlike mitigation efforts, which often generate clear returns – adaptation is viewed as public global good.

For example, while tourism flourishes in Senegal due to its beautiful coastlines, private operators are not incentivised to invest in seawall protection, as the present costs are enormous and the benefits would accrue far into the future. In contrast, the provision of solar systems to households offers immediate returns, though the entry capital expenditure is high. Work is increasingly underway to put a private value on adaptation projects to help crowd-in private investment. Since many countries on the continent are still in the early stages of development, the cost of transitioning to improved water irrigation systems or adopting integrated water resource management to deal with floods, droughts, and other weather events is prohibitive. But building resilience today will save substantial resources in the future. The energy access issue is also an adaptation challenge for the continent, as many have no access to energy and last-mile energy provision is often not compatible with expected market returns.

Dealing with air pollution is another, increasingly large, climate adaptation challenge for Africa. Air pollution is a leading cause of deaths across many African countries, particularly among children. In addition to its toll on human health, air pollution imposes economic costs, which are set to increase. A recent study found that the economic output lost to air pollution-related disease in 2019 was \$3.0 billion in Ethiopia (or 1.16% of the nation's GDP), \$1.6 billion in Ghana (0.95% of GDP), and \$349 million in Rwanda (1.19% of GDP) (Fisher et al., 2021).

One major barrier to adaptation investment lies in how these projects differ from mitigation efforts. Mitigation investments benefit from years of financial structuring and innovation, well-established revenue streams, and risk-adjusted financial returns. By contrast, resilience projects often generate broad social benefits rather than direct profits, involve long implementation periods, are typically bespoke, and lack clear performance indicators. As a result, resilience projects are grossly underfunded. While the annual funding need for resilience is projected to be \$387 billion by 2030, only \$63.5 billion was mobilised as of 2022, leaving a \$323.5 billion gap. Moreover, the distribution of funding is uneven, exacerbating regional disparities in resilience.

## THE ROLE OF CLIMATE FINANCE

Climate finance is critical for achieving Africa's climate targets, as presented in its Nationally Determined Contributions (NDCs). These targets range from transitioning away from fossil fuels and adopting more carbon-neutral technologies, to adopting more resilient agriculture techniques and building techniques, to protecting nature and biodiversity. Africa's climate finance flows must at least quadruple annually until 2030 to meet the investment needs for implementing its countries' current NDCs (CPI, 2024).

Access to climate finance, however, is constrained by both internal and external factors. Africa's fiscal space is constrained by its inability to raise resources domestically, ineffective public expenditure, high risk perceptions, high debt service burdens, and falling levels of foreign direct investment. Externally, the availability of finance is not increasing at the pace required. Concessional resources are shrinking: in 2024 alone, over 40% of global development finance was reallocated to new and emerging needs, particularly those arising from the war in Ukraine and associated migration pressures. Africa receives less than 3% of global climate finance, despite being home to 17% of the global population and facing over 40% of global climate vulnerability risks (CPI, 2024).

Private finance is crucial for climate investment in Africa, but its scale has also been disappointing. Participation is constrained by both real and perceived risks, limited project pipelines, and insufficient returns. Going forward, more needs to be done to increase private sector participation, including by working more with national development banks, pension funds, insurance, and others in a public-private framework and by supporting the development and use of innovative instruments.

Investing simultaneously in adaptation and mitigation builds systemic resilience. Ultimately, the goal is to foster economies that are not only low-carbon and climate-resilient, but also prosperous and inclusive.

Generally, adaptation is underfunded due to its public commons nature. Globally, adaptation finance accounts for less than 27% of all climate finance. According to a UNEP report, Africa needs between \$50-100 billion per year for adaptation by 2030 (UNEP, 2015), while an OECD report indicates that the continent only received \$11.4 billion in 2021 (OECD, 2021) – less than 23% of its total needs in the optimistic scenario, where the definition of adaptation is more broadly defined.

According to the Climate Policy Initiative (CPI), mitigation accounted for around \$18 billion of the roughly \$29.5 billion that Africa received in 2021 for climate projects. This represents only 8% of the continent's mitigation needs. A further challenge is that the investment gap grows every year that annual targets are missed. Furthermore, financing remains highly concentrated: just ten countries received over 50% of all climate finance going to Africa, and the same number of countries captured 76% of all private sector climate investment in the region.

## SOURCES OF FINANCE

Domestic finance will remain the main source of climate finance for most African countries. Countries must therefore focus on strengthening domestic revenue mobilisation, making expenditures effective and efficient, and making better investments.

### Tax revenue

On average, most Africa countries collect tax revenues equal to about 18% of their GDP. While this number has increased, it remains substantially lower than other regional averages (over 25% in Asia and over 30% in Europe). In a global low-growth environment, countries must look towards improvements in tax policy.

VAT rates on the continent are generally around 15-20%, on par with developing country averages, but compliance is an issue. Technology-driven tax systems could help broaden the tax base, enhance compliance, and improve revenue collection. Indeed, more effort is needed across the continent to broaden the tax base, including through new taxes such as on services and real estate. As more cities emerge and incomes increase, the tax base should improve.

### Carbon markets

On the climate front, the most promising source of additional revenue is carbon credits, and a strategic shift towards compliance carbon markets is crucial (see Chapter 8 by Cantillon, Lambin and Weder di Mauro in this volume). The size of the global carbon credit market was estimated at \$669.37 billion in 2024 and it is predicted to grow to approximately \$16.3 trillion by 2034.<sup>7</sup> Over a third of this increase is set to come from compliance mechanisms. For example, the price of emissions allowances traded on the European Union's Emissions Trading Scheme (EU ETS) exceeded €100 per metric ton of CO<sub>2</sub> for the first time in February 2023, though it has since fallen back to around €70.<sup>8</sup>

Africa stands to benefit substantially from well-developed carbon and nature markets, but such markets are still nascent on the continent. African countries have collectively earned a meager \$1-1.5 billion from carbon credit sales, primarily through voluntary carbon markets.<sup>9</sup> This is well below the continent's potential. The African Carbon Markets Initiative (ACMI) was launched recently to help harmonise and regulate the market, in order to attract more investors as well as to protect Africa's biodiversity and nature. As African countries develop the regulatory framework for carbon markets, they must move from voluntary frameworks to more compliance-based ones. Notable carbon credit projects include those in Ethiopia, Nigeria, and Gabon.

7 <https://www.precedenceresearch.com/carbon-credit-market>

8 <https://www.statista.com/statistics/1322214/carbon-prices-european-union-emission-trading-scheme/>

9 <https://www.goldstandard.org/news/africa-can-harness-the-global-carbon-markets-to-advance-climate-and-development-goals>

The integrity, governance, and transparency of the framework is the single most important component of a successful carbon market scheme. With the use of technology, such as block chain, issues of measurement, reporting and verification (MRV) are easier to address. Other issues that need to be addressed include market fragmentation, community inclusion, and capacity development. Appropriate revenue-sharing schemes are also an important component in the design of carbon projects.

The finalisation of operational rules for Article 6 of the Paris Agreement at COP29 in Baku represents a critical step forward (see Box 1). These rules should unlock progress towards harmonised, functional carbon markets and support developing countries in transitioning to compliance regimes.

#### **BOX 1 SUMMARY OF THE RELEVANT SUBSECTIONS OF ARTICLE 6 OF THE PARIS AGREEMENT**

Article 6.2 enables bilateral or multilateral trading of emissions reductions, known as Internationally Transferred Mitigation Outcomes between countries.

Article 6.4 establishes a centralised UN-supervised carbon market, allowing for the generation and trading of emission reduction credits from approved projects.

Article 6.8 facilitates non-market approaches, such as technology transfer and capacity building, to support mitigation and adaptation efforts without relying on carbon trading.

Source: IPCC.

### **Removal of subsidies**

Countries must also rationalise and increase the efficiency of their public spending. Across the world, over 7.1% of global GDP, or \$7 trillion, was spent on fossil fuel subsidies in 2022. This figure includes direct and indirect subsidies offered to consumers and to firms for direct consumption, as well as the cost of third-party externalities (i.e., the costs of associated health care and environment damage). More than half of African countries have some form of fossil fuel subsidy, with the subsidies in Angola, Nigeria, Senegal, Morocco and Egypt among the biggest. Senegal's fuel and electricity support was equal to 4% of GDP in 2024, while Nigeria spent \$10 billion capping the price of petrol. Angola spent 1.9 trillion kwanza (\$2.3 billion) in 2022, which is more than 40% of the country's estimated spending on social programmes. In South Africa, government support for oil and gas, electricity that is largely generated from coal, and carbon tax exemptions tripled between 2018 and 2024.<sup>10</sup>

<sup>10</sup> <https://www.bloomberg.com/news/articles/2024-04-10/south-africa-fossil-fuel-subsidies-top-6-billion-study-shows?embedded-checkout=true>

Removal of fossil fuel subsidies has been a thorny issue on the continent. While countries are increasingly recognising the need to remove such subsidies, political pressures have made this difficult to achieve. In Nigeria and Kenya, for example, attempts to remove subsidies led to widespread strikes and political unrest. In addition, with high inflation post-COVID, policymakers are weary of a potential inflationary impact of subsidy removal on prices. Many countries that had embarked on subsidy removal reintroduced them after the 2020 COVID pandemic to ease the cost for consumers.<sup>11,12</sup>

In addition, subsidies for liquefied petroleum gas (LPG) in some countries have proven effective in incentivising populations to protect forests, and policymakers are weary of backsliding if the subsidies were to be removed. Most of these issues can be managed with better targeting, thus freeing up resources for climate adaptation or mitigation investments.

### **Domestic capital markets**

Domestic capital markets could play a much greater role in financing the green economy, while also reducing exposure to exchange rate risk and external debt distress. Currently, international sources provide 87% of Africa's tracked climate finance, despite Africa having around \$2.4 trillion of bank, insurance, and pension assets under management domestically. These numbers demonstrate not only the very limited involvement of African domestic institutional investors in climate-positive investment on the continent, but also the enormous potential to strengthen and leverage domestic markets to increase domestic flows.

Monitoring domestic investments is difficult because detailed data specifically linked to climate-related factors is lacking (CPI, 2024). To understand and bridge this gap, detailed country-level assessments are needed. In addition, growing interest in the ability of national development banks and regional banks to deploy local currency capital is in turn driving attention to how domestic capital streams can be better leveraged to support national climate agendas.

The insurance gap – the difference between economic losses from disasters and the portion covered by insurance – remains a critical issue in climate risk management, and particularly in high-risk developing regions where insurance remains unaffordable or unavailable. In South Africa, for instance, the insurance gap is estimated at 83% (Allianz, 2025). Limited access to affordable insurance leaves governments businesses and individuals vulnerable to catastrophic financial losses.

11 <https://thearabweekly.com/egypt-cut-fuel-subsidies-it-seeks-reduce-current-account-deficit>

12 <https://www.reuters.com/world/africa/morocco-pause-subsidies-reform-due-geopolitical-uncertainties-minister-2023-10-13/>

## External finance

The scope for external financing of Africa's climate agenda has widened, with multilateral development banks (MDBs), regional development banks, IFIs, bilaterals, insurance companies, commercial banks, asset management companies, and philanthropy all involved in financing the continent's green transition and resilience-building agenda. But despite the multitude of external financing options, the gap between what is needed to finance climate mitigation and adaptation in Africa and what is being funded is widening. It is estimated that Africa needs \$190 billion annually to implement its collective NDCs (FSD Africa 2025), but annual climate finance flows to the continent are only about US\$44 billion (23% of the estimated need).

Multilateral development banks remain the most important partner in the climate transition in Africa because of the longer-term and affordable concessional capital they can provide both directly as loans and, in some cases, as equity in projects. They play an important role in the climate finance capital stack, providing blended finance tools.

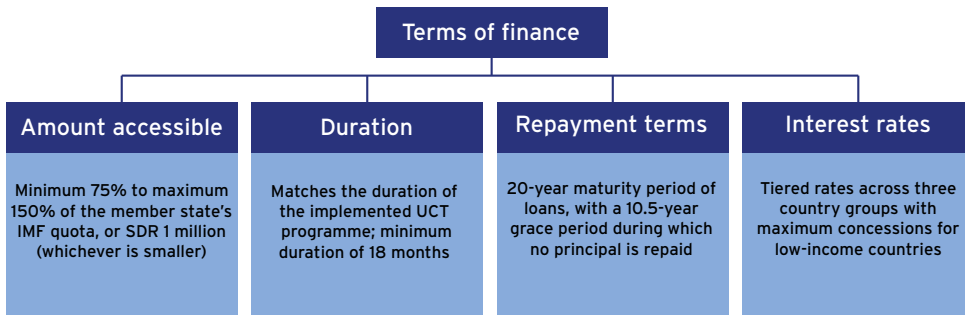
MDBs are allocating more capital to climate-related projects. According to the 2023 joint MDB report, they spent over \$74.7 billion on climate-related investments in 2023 compared to \$41.5 billion in 2019 (African Development Bank et al., 2024). Africa received over \$17 billion of this, with about 65% going to mitigation and 35% to adaptation. The International Development Association (IDA) priced its first two aligned sustainability deals in September 2024 for a combined \$2.8 billion. This was split between a \$2.5 billion seven-year deal and a \$300 million six-year deal.<sup>13</sup> The African Development Bank (AfDB) priced a \$2 billion aligned social deal in September 2023. The AfDB three-year bond references the AfDB's 2023 sustainable bond framework which lists five social project categories: affordable basic infrastructure, access to essential services, food security and sustainable food systems, employment generation and programmes, and socioeconomic advancement and empowerment.

The aim is that, over time, MDBs can increasingly use their funding to help improve the risk-adjusted returns of projects and thereby attract more investments into the continent.

In addition, 15 African countries have accessed the IMF's Resilience and Sustainability Trust (RST). The RST's lending facility, the Resilience and Sustainability Facility (RSF), provides affordable financing to help eligible IMF members address longer-term structural challenges – including climate change and pandemic preparedness (IMF, 2024). While the RST is biased towards mitigation, over 40% of the funds on average are for general public finance projects (Dimond and Gupta, 2024).

13 <https://www.climatebonds.net/data-insights/publications/sustainable-debt-market-summary-q3-2024>

FIGURE 3 HISTORIC LONG-TERM FINANCING OF THE RESILIENCE AND SUSTAINABILITY TRUST



Source: CEEW-GFC analysis based on the IMF's factsheet on the Resilience and Sustainability Facility.<sup>14</sup>

### Green bond markets

Green bond markets are becoming increasingly important in the sustainable financing landscape. Total global green bond issuance is estimated to have surpassed \$3.4 trillion in 2024, with most focused on climate mitigation projects. As the market for sustainable bonds develops, so have the instruments available to sovereigns and corporates. The introduction of sustainability-linked bonds (SLBs)<sup>15</sup> – where the financial or structural characteristics, such as the interest rate or maturity date, are tied to the issuers' achievement of specific sustainability or ESG targets – and transition bonds in 2023 has diversified the landscape further. The difference between these debt instruments is mostly in the use of the proceeds, with green bonds being earmarked while sustainability-linked bonds and transition bonds have more flexibility.

According to the International Finance Corporation (IFC) and Amundi, the sustainable finance market in general – and green bonds in particular – continues to grow, offering a promising source of climate finance for the developing world. The impact of the ongoing climate crisis in Africa and the continent's wealth of natural capital make it a potential market for green bond proliferation. However, low liquidity and underdeveloped capital markets across Africa have limited the potential of green bond markets (Nkombo, 2024). Africa's share of the global \$2.2 trillion green bond market is less than 1%. Over the past decade, green bonds on the continent have grown at a compound annual growth rate (CAGR) of 20%, a much slower pace than in Asia-Pacific and Latin America (70% and 43%, respectively, over the same period).

Despite this, green bond issuances in Africa grew by 125% in 2023 to reach \$1.4 billion, up from \$600 million in 2022 (Nkombo, 2024). As of 2024, Africa had issued over 20 green bonds in countries including Tanzania, Rwanda, Gabon, Seychelles, Nigeria, South Africa, Kenya, Morocco, Mozambique, Namibia, Mauritius and Zambia. These green bonds have funded climate mitigation and adaptation projects, including renewable

<sup>14</sup> <https://www.ceew.in/gfc/quick-reads/explains/imf-resilience-trust>

<sup>15</sup> Rwanda issued the first SLB in Africa in 2023; South Africa and Kenya have since issued SLBs as well.

energy, forestry, sustainable agriculture, sustainable water and clean transport projects. One of the largest sovereign sustainable bond issuances in 2024 was the \$1.1 billion Côte d'Ivoire Sustainability Bond, which will be used for eligible green projects in line with the ICMA 2021 and CBI 2023 Green Bond Principles.

### Debt-for-nature swaps

Debt-for-nature deals are becoming increasingly popular among poorer nations to pay for conservation. Bonds or loans are bought and replaced with cheaper debt, with savings used for environmental protection (see Box 2 for an example). The biggest drawbacks of debt-for-climate swaps are their size and the difficulty of replicating and scaling.

#### BOX 2 AN INNOVATIVE DEBT-FOR-ENERGY SWAP BETWEEN GERMANY AND KENYA: A BLUEPRINT FOR THE ENERGY TRANSITION

Kenya's debt-for-climate swap with Germany is an innovative deal that illustrates how countries can remain fiscally prudent while investing in new green infrastructure.

Kenya is among the top ten geothermal energy-producing countries in the world. As part of its green climate development strategy, it has committed to increase its energy supply by increasing geothermal energy production. However, Kenya is facing substantial fiscal pressure. Debt service accounts for over 45% of the national budget and 55% of government revenue. The country spends more on debt service than on new investments, health and education. It must therefore look to other sources of cheap finance for new investments.

With this aim, Kenya concluded a debt-for-climate swap with Germany, one of its creditors. This innovative deal, the first of its kind on the continent, could inspire other countries seeking sustainable solutions to debt and climate challenges. The project is contingent on Kenya's finalisation of the Bogoria Silale geothermal power plant, which forms part of the country's green climate strategy. The debt relief will be provided at the end of the project and is not a use of proceeds-type structure. This means Kenya still has to raise the resources for the construction of the project. However, the \$60 million debt relief amount could be used to bring down the overall cost of the loan and reduce Kenya's upfront contribution.

### Blended finance

Blended finance, if well structured, offers a critical mechanism for aligning public and private sector priorities in climate funding. It involves leveraging concessional public funds to attract private capital, ensuring that investment flows into projects that might otherwise be deemed too risky or unprofitable. This approach requires collaboration among a wide range of stakeholders, including government, philanthropic organisations, and development organisations. Blended finance depends on effective regulatory environments and the right policy framework. Challenges that must be addressed to increase uptake include high transaction costs and the complexity involved in structuring some of the deals, which make them impossible to replicate and non-transparent. In some

cases, rather than lowering risks, the use of blended finance tools increases risk perception and distorts markets, which can be detrimental in countries that are struggling to get ahead. Green, resilience operations are especially prone to these risks because they tend to be innovative and do not rely on precedent for pricing or risk weights. Countries must build capacity to understand how to price the risk of their projects and how best to deploy the capital stack available to them for effective project development.

#### BOX 3 NIGER'S GOROU BANDA SOLAR FARM

An example of a successful green blended finance project is the Gorou Banda Solar Farm in Niger. This 50MW power station, with over 55,000 panels, is the largest solar facility in the country, providing clean energy to Niamey and nearby regions. It has played a crucial role in addressing electricity shortages after Nigeria halted power supply following the July 2023 coup. The plant was built under a build-own-operate-transfer (BOOT) model. Funding for the initial project was structured as a public-private partnership facilitated by the Government of Niger, which provided equity capital, with IFC support through the Scaling Solar programme, which provides both project development grant financing and debt financing for the project, as well as addition financing from the French development agency and the European Union. The project is expected to power about 200,000 households as well as reducing greenhouse gas emissions as a result of the reduction in use of fossil fuels and burning of wood. It is also expected to drive economic development and employment.

#### Climate funds: Dedicated financing tools

Climate funds were established to fill the gap in financing needed to help countries transform and transition their economies. There are four large climate funds: the Green climate fund (GCF), the Adaptation Fund, the Global Environment Fund, and the Climate Investment Fund.

The Brazilian G20 presidency launched a review of the performance of these climate funds (G20 Brazil 2024), which identified a number of areas of improvement that could help increase the flow of financing to Africa and other emerging countries. Top of the list was the need to accelerate disbursements. While over \$4-5 billion was committed each year, less than 25% of the funds were disbursed. Also relevant for Africa in particular, the report identified a substantial imbalance between adaptation and mitigation funding. Over 90% of all resources allocated were for mitigation projects, an area where other sources of funding are scarce and where public funding is most needed. Nature and biodiversity projects, an area in which Africa could develop more cost recovery projects, are heavily underfunded, mostly due to challenges with measurement, reporting and verification.

Climate funds are best placed to support countries in tackling the more difficult institutional development and project preparation issues facing adaptation projects. Fulfilling this role could also help improve synergies between climate fund financing and public and private sector projects. A clearer definition of the funds' mandates and greater focus on adaptation are important areas for development. Private sector equity funding of climate change in Africa is dominated by domestic firms. Over 40% of all equity funding into green investments on the continent comes from the domestic private sector. More resources will be needed to help build capacity and the climate funds could be mandated to do this.

### **CLIMATE FINANCE IN A HIGH-DEBT ENVIRONMENT**

Over 60% of low-income countries are in debt distress or at high risk of debt distress, limiting their ability to take on additional debt. While finance is scarce and costly, most of the external finance available to support the transition will remain debt finance, despite more effort being focused on domestic resource mobilisation and grant financing. In this context, countries must focus on obtaining long-term 30-40 year concessional finance; this is especially important as adaptation expenditures take a long time to deliver returns. The current uncertain and volatile economic environment is exacerbating the challenges. The threat of a global crisis looms large. Low- and middle-income countries cannot confront the climate challenge on their own.

A recent report commissioned by the governments of Colombia, Kenya, France, and Germany offers timely and actionable recommendations to address these interconnected crises (Expert Review on Debt, Nature and Climate, 2025). Among its key suggestions is a call for the IMF to revise its Debt Sustainability Analysis (DSA) framework to better incorporate nature and climate risks. The report urges the international community to break the 'vicious circle' of rising debt, accelerating climate change, and nature loss, so countries can invest in building resilience. The main recommendations are summarised in Box 4.

### **PRUDENTIAL REGULATION AND CLIMATE FINANCE<sup>16</sup>**

Integrating climate considerations into prudential regulation is essential for safeguarding Africa's financial stability and promoting sustainable economic growth. By addressing current challenges and implementing targeted strategies, African regulators can enhance the resilience of their financial systems to climate-related risks.

16 This section draws on Noss et al. (2024).

#### BOX 4 MEASURES TO REDUCE THE DEBT BURDEN OF LOW- AND MIDDLE-INCOME COUNTRIES WHILE ACCOUNTING FOR CLIMATE AND NATURE IMPACTS ON ECONOMIES

Many EMDCs are confronted with a triple crisis of high debt, climate, and nature. In addition, they are now facing net capital outflows due to interest repayments exceeding new lending (totaling around \$4 billion in 2023 for low- and lower-middle-income countries) and the fact that business leaders surveyed by the World Economic Forum 2025 see environmental risks as one of the top barriers to global growth. A holistic response to the triple crisis is critical to break the vicious circle and shift to a virtuous one of green and resilient economic growth. The report proposes the following five broad measures:

- The IMF and World Bank should revise their Debt Sustainability Analysis models to better incorporate nature and climate risks and the economic benefits of reducing them using stock flow consistent model, and the credit ratings agencies to follow suit. Developed and other creditor countries and the IMF should provide new programmes enabling EMDCs in different circumstances to restructure or refinance their debts to support climate-resilient and nature-smart development and growth plans.
- Multilateral development banks, borrowers, and creditors should expand the range of climate-and nature-related financial instruments, such as climate resilient debt clauses, debt-for-nature and debt-for-climate swaps, and sustainability-linked financing.
- Donor countries, the private sector, and MDBs should develop innovative new financial instruments, including the securitisation of future aid flows, to provide new sources of finance at scale for climate and nature investment in EMDCs. In particular, the study recommends that a special purpose vehicle, the Finance Facility against Climate Change (F2C2), be established to unlock up to \$1 trillion from capital markets through the issuance of green bonds securitised by future ODA commitments. Bond receipts would be earmarked predominantly for climate-mitigation investments in EMDCs.
- EMDCs and DFIs should work together to develop new equity-like instruments to finance resilience infrastructure, which will better align repayments with real fiscal savings. Repayments will be later, and more closely linked to the returns on investment, but potentially much higher than returns on traditional debt instruments.
- International financial institutions and the UN regional economic commissions should establish a 'one-stop shop' for technical advice to EMDCs on sustainable debt management.

Source: Expert Review on Debt, Nature and Climate (2025).

Financial institutions play a pivotal role in how climate finance is mobilised and deployed. In particular, they can provide funding for projects aimed at reducing climate change and preserving natural ecosystems, supporting countries and corporations with their transition. The financial sector is expected to be responsible for most of the financing required, as 80% of the emissions emanate from G20 countries with active financial sectors. China, the United States, Europe, Brazil, and India account for the largest share

of emissions.<sup>17</sup> On the debt front, the climate debt market was a \$4.4 trillion market in 2023 (Climate Bond Initiative, 2024), encompassing green, social, and sustainability-linked bonds. Financial institutions were the second-largest issuer type, with a 28% share of aligned green volumes. Energy, buildings, and transport remained the three largest use-of-proceeds categories, collectively contributing 75% of the green debt volume for the financial sector.

The Network for Greening the Financial System (NGFS) and the Basel Committee on Banking Supervision (BCBS) have played an important role in highlighting the importance of addressing climate-related risks in the financial sector.<sup>18</sup> Beginning in 2021, banks began to report not only their exposure to carbon-intensive sectors but also their actions to reduce their own/direct emissions (scope 1), indirect emissions via clients (scope 2), and other-related businesses/portfolio-related emissions (scope 3). The disclosure provides useful information to financial regulators on the nature of banks' exposure to climate risks (for example, broken down by sectors and materiality). It is important that African banks do the same.

Prudential regulators need to understand how climate finance can expose banks to various risks. The BCBS (2021) provides a framework that banking supervisors can use to identify risks faced by banks arising from their climate finance activities. It describes how banks and the banking system can be exposed to climate risk drivers through traditional risk categories. For example, transition risk drivers (government policy, technological change, consumer sentiment) can be transmitted through microeconomic channels (households, corporates, sovereign), leading to increased credit risks for banks (e.g., through their lending portfolios).

'Greenwashing' risk arising from climate finance activities of banks is a major prudential concern. The NGFS (2023) highlighted that greenwashing is one of the most common forms of climate-related litigation against financial institutions and that the trend of increasing greenwashing litigation can be expected to continue, in particular due to increasing regulatory oversight of climate-related disclosures by firms. Banks can engage in greenwashing by making misleading statements on the current sustainability characteristics of their climate finance activities, or the sustainability results/real-world impact of those activities or their future sustainability commitments. A concrete example is providing 'green retail loans' that are not used to finance activities that qualify as being 'green' under a recognised taxonomy. A global framework of interoperable taxonomies is essential to provide certainty and consistency in investment and financing, supporting the harmonisation of prudential standards and enhancing risk management in the

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<https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters>  
See BCBS (2021) and NGFS (2021).

financial sector. African central banks and commercial banks will need to accelerate their Basel III compliance levels in order not to be left out of these markets. Nigeria and South Africa are the most advanced in these areas, but more effort is needed to support data collection, disclosure, and supervision of these institutions.

## CONCLUSION

Africa's climate crisis is global in its implications. The continent is home to critical natural and biodiversity assets that underpin the stability and prosperity of the entire planet. Yet, while the need for investment to protect these assets and build resilience is urgent, Africa continues to fall short in mobilising the finance required to meet this challenge, and institutions – both global and domestic – continue to fall short of expectations.

African countries must pursue a dual strategy: significantly scaling up domestic resource mobilisation while improving their ability to access international capital. Strengthening fiscal systems, enhancing policy coherence, and creating enabling environments for investment are essential steps. But domestic efforts alone are insufficient. Africa's access to affordable, long-term, and concessional finance must improve, particularly for adaptation, where returns are less immediate but profoundly transformative.

Domestic resources alone will not meet the challenge; increased efficiency in the use of resources is crucial, and Africa must improve its access to capital markets. Multilateral institutions, development banks, and private investors must work with African stakeholders to co-design and co-finance projects that align with national priorities and deliver both environmental and developmental dividends. The evolution of instruments like green and sustainability-linked bonds, and innovative mechanisms such as debt-for-climate swaps, presents promising avenues that should be scaled and adapted to diverse national contexts.

Ultimately, climate finance in Africa cannot be treated as a siloed or peripheral issue. It is a foundational pillar for inclusive development, resilience, and long-term prosperity. With the right investments and governance, Africa can emerge not only as a victim of climate change, but as a vanguard of green industrialisation, climate-smart development, and global stewardship.

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# CENTRE FOR ECONOMIC POLICY RESEARCH

The Third Paris Report calls for a bold new global strategy to align climate, nature, trade, and finance. With emerging economies central to future climate outcomes, the report outlines a four-pillar plan - carbon pricing coalitions, clean energy investment, green industrial partnerships, and innovative carbon removal markets. In a fragmented world, it urges coalitions of the willing to drive a just, nature-positive transition. This report forms the second output from a joint initiative between CEPR and Bruegel: Important Topics of Common European Interest (ITCEI).

The report is made up of twelve chapters that take stock of the state of international climate cooperation under the Paris Agreement and beyond, examine the macroeconomic implications of climate change mitigation, develop new policy approaches to reduce emissions and restore nature, and undertake regional analyses of India, Africa, the Amazon and emerging and developing economies overall. An introduction from the report's editors brings together the principal lessons from the report in a four-pillar strategy to accelerate climate and nature action.

The editors, Jean Pisani-Ferry (Sciences Po, Bruegel and CEPR), Beatrice Weder di Mauro (Geneva Graduate Institute, Hoffmann Center, INSEAD, and President, CEPR) and Jeromin Zettelmeyer (Director, Bruegel, and CEPR), lay out a coherent, actionable plan for advancing the global commons in an era of political fragmentation. It draws on the strengths of advanced economies, the renewable potential of developing nations, and the growing role of subnational actors to propose variable-geometry coalitions capable of moving the needle where universal frameworks have stalled. The result is not only a set of proposals, but a blueprint for climate and biodiversity action that is as realistic as it is ambitious.

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