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GREEN INTERSECTIONS

The global embedding of climate change in policy

Edited by Heather Grabbe
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Heather Grabbe and Simone Tagliapietra

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1 How climate action is reshaping global public policy: an introduction

Heather Grabbe and Simone Tagliapietra

Green objectives have reshaped public policy worldwide over the past decade. Since the 2015 Paris Agreement, international cooperation under the United Nations Framework Convention on Climate Change has driven action across a wide range of public policies to limit emissions of greenhouse gases and to adapt to a changing climate. Through all layers of government – from city mayors to international organisations – recognition has spread that a stable climate is the ultimate global public good, and achieving it will require an unprecedented effort at coordinated international action. Climate policy has moved from being one policy among many to an objective embedded in a wide range of public policies at every level, from energy, industrial and fiscal to trade, development and foreign policies.

However, despite widespread commitments to that principle among public and private organisations, the practical achievements are far from sufficient, with emissions still rising and climate impacts intensifying even faster than predicted by scientific models. Although many governments and organisations have adopted strategies containing commitments to reduce their environmental impact, far fewer are on track to reach even the targets they set themselves, let alone to achieve the reductions necessary to stabilise the climate. Projections indicate that current policies will lead to a rise in global temperature by 2.7 degrees Celsius at the end of the century (Ellis *et al*, 2024), an increase that would have substantial global consequences for living conditions, public health and the economy.

The role of public policy has become all the more important now that, ten years after the Paris Agreement, the global climate agenda has suffered significant setbacks. President Trump withdrew the United States from the Paris Agreement for a second time in 2025. His administration also began promoting fossil fuels, dismantling President Biden's incentives for the manufacturing and roll-out of clean technologies, and suppressing scientific research and data-gathering on climate change in both domestic and international organisations. US tariffs are causing disruption to trade, with potential effects on global supply chains for clean technologies, and uncertainty is deterring investment. Some governments and companies have followed suit by lowering their climate ambitions.

These chapters were written before Trump's return to power and subsequent US policies that have disrupted trade, deterred investment, reduced development assistance and weakened international institutions for global governance. Yet the fundamental trends identified in this volume continue across many regions and sectors. There is dynamism in the green transition despite the chilling effects of geopolitical realignments, trade wars and security tensions. The transition continues to drive significant policy changes as many governments and companies seek to reduce their exposures to vulnerable supply chains, fossil-fuel imports and climate impacts, while others seek to play leading roles in the ongoing green industrial revolution. Moreover, during the past ten years of stronger climate action, much has been learned both about what works in climate policy and how other policies are shaped by net-zero commitments. These lessons should not be wasted, and this volume aims to gather significant relevant experience from a range of sectors and regions.

The chapters in this volume map out how climate action is interacting with trade, finance, industrial and development policies. Global thought-leaders in these fields analyse the interconnections between climate policies and other trends across sectors and geographies. Policy debates often fail to take into consideration these interconnections, focusing just on one sector or objective, and they are often dominated by old dilemmas rather than the new ones brought by the green transition. These essays offer precious insights from across these usually fragmented policy areas.

Among the policy objectives that are proving resilient to political opposition to climate action, renewable energy deployment stands out as largely robust. After all, even during the first Trump presidency, renewable energies kept rising in the United States, driven by strong market fundamentals. The economic logic of low operating costs favours renewable energy once the capital investment has been made in clean tech and infrastructure such as grids and storage. Geopolitical risks make independence from fossil fuel imports more attractive, especially for importing countries. The 2022-2023 European energy crisis has a clear story to tell in this regard. More renewables also enhance energy security when infrastructure can come under attack from sabotage as well as military operations. Jason Bordoff maps out the intricate landscape of diversification of energy sources and the impact of climate change itself on energy security. Both old dependencies on fossil-fuel sources and new ones on clean tech can be weaponised, so strengthened international alliances are needed to mitigate geopolitical dangers.

The green transition is sometime defined as an industrial revolution against a deadline. Industrial policy has been fundamentally reshaped by the green transition, opening up new avenues of technological innovation and paving the way for the emergence of a new manufacturing basis. No country in the world has invested more than China in this area. The country’s contribution to the supply side of the green transition, writes Wensheng Peng, is an industrial policy for clean technology industries that has resulted in economies of scale in manufacturing and technological advances that have driven down prices and increased supply globally. But climate objectives have also driven a revival in industrial policy in Europe and the US (at least under the Biden administration). Ketan Ahuja and Ricardo Haussman examine the roles of public policy in shaping supply, demand and market conditions for decarbonisation, particularly the mutually enhancing role of industrial policy and competition policy.

However, the rise in geopolitical tensions and uncertainty exacerbates major challenges for public policy related to climate objectives. It is particularly detrimental to sustained capital investment.

The gap between investment needs and availability is widest in the Global South, where the cost of capital remains high for developing countries. In many developing countries, securing the initial capital investment remains a huge problem even if they have abundant solar and wind potential. Avinash Persaud points to the potential for reducing the prohibitive cost of capital in developing countries, particularly by reducing currency risk. Rim Berahab and Karim El Aynaoui also list financing as a vital missing link for green energy policies in Africa, alongside governance, inadequate infrastructure and small domestic markets. However, the diverse experiences of Kenya and Morocco show how much can be achieved with pro-active public policy and effective regulation to install renewables that improve energy access while also reducing carbon emissions.

International governance to coordinate efforts and bring more finance to developing countries would help to resolve policy dilemmas. The question is how to improve it during the US absence from global climate governance. Zhou Xiaochuan argues for more China-Europe cooperation across a range of policies. Ruud de Mooij and Vitor Gaspar set out the case for an international agreement on a minimum carbon price so that governments can escape the trilemma between spending to meet climate goals, keeping public debt sustainable and avoiding political red-lines on taxation. Mauricio Cárdenas presents an agenda for more inclusive global frameworks for access to clean-energy technologies and fair trade to prevent the North/South divide in development from widening as a result of both the direct effects of climate change and the global policy responses to it, while Jomo Kwame Sundaram analyses the global injustices inherent in climate change and ostensible efforts to address them.

In Europe over the past five years, a nexus has grown between climate, energy and industrial policies that have also shaped the EU's foreign policies, as explored by Margherita Bianchi and Nathalie Tocci. The European energy transition is bound to continue because of concerns about reducing reliance on expensive imports of fossil fuels, especially from Russia. However, wider green goals have been at least temporarily eclipsed by a drive to build up defence, and the EU's approach to climate mainstreaming in foreign policy lacks a long-term vision. Although Europe performs well on climate finance, contributing half of global climate funds, it failed to engage early enough with other regions on trade policies motivated by climate objectives – most notably the external application of its carbon pricing policies.

Overall, these essays show that in many countries and in many policy areas, green objectives are still driving fundamental changes. Amid the daily political drama, it is easy to lose sight of the longer-term structural changes that climate mitigation and adaptation efforts are causing across a range of policies in Europe, China and Africa and other parts of the Global South. In many cases, greater support from political leadership and international cooperation is needed if policies are to succeed in reducing emissions and enhancing economic and societal resilience to climate change. However, these policy goals are likely to persist over the next years as climate impacts become more evident in many regions and the green transition produces successes at city, regional and national levels. We hope that this Bruegel Blueprint offers a fresh intellectual framework for understanding how the green transition is shaping cross-sectoral impacts across the globe.

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2 Green geopolitical revolution: navigating the geopolitics of the energy transition

Jason Bordoff

2.1 Introduction

The once optimistic vision that the global transition to clean energy would simplify geopolitics has been shattered by the chaotic reality that has unfolded in recent years. Energy crises, exacerbated by the COVID-19 pandemic and Russia's invasion of Ukraine, have underscored that the path to a decarbonised world is fraught with new and complex geopolitical risks. These challenges have brought the concept of energy security – once a fading concern during decades of energy abundance and relatively stable global markets – back into sharp focus. Energy security is no longer just about ensuring sufficient supplies at affordable prices; it involves navigating a far more intricate landscape of diversified energy sources, geopolitical rivalries and the stark realities of climate change.

The global push toward a green transition is reshaping the geopolitical landscape and energy markets. The stakes are higher than ever. In 2024, the world witnessed its warmest year on record. Alarming events, such as the deaths in temperatures soaring to nearly 50 degrees Celsius of over a thousand Muslims making the pilgrimage to Mecca, and climate and weather-related disasters in the United States exceeding $100 billion in costs, underscore the urgency of decarbonising the energy system, even as global conflicts highlight risks to energy security, creating a complex and often contradictory set of priorities for policymakers and market players. A deeper understanding of the entanglement of geopolitics with energy and climate change is crucial if the world is to address not only the climate crisis, but also broader challenges, including global economic development, international peace, humanitarian objectives and many other pressing foreign policy problems. Energy transition is not only a goal in itself; it is also a strategic tool that, if used wisely, can help mitigate some of the most pressing current geopolitical dangers.

Meghan O'Sullivan and I have written on this topic in several essays in *Foreign Affairs*, which delve into the interconnections between the energy transition and global stability. This chapter draws on that work. The geopolitical landscape is being redefined by the struggle for resources, rising economic nationalism and the complex relationship between energy independence and interdependence. From the stark lessons of Europe's reliance on Russian gas to the growing tensions between the US and China over clean-energy supply chains, this chapter provides an overview of the geopolitical risks and opportunities on the path to a low-carbon future.

As traditional energy superpowers are joined by new and emerging clean energy powers, governments are increasingly stepping into energy markets to safeguard both economic and environmental interests. This moment of upheaval, however, also provides an unprecedented chance to reimagine a global order that addresses the inequalities and instabilities created by fossil fuels. By treating climate goals as drivers of peace and cooperation, the energy transition could not only mitigate climate risks but also serve as a foundation for a more stable, prosperous and interconnected world. To achieve a successful transition, the energy shift should be viewed not as a single challenge but as a transformative opportunity to rethink global power dynamics, strengthen international alliances and embrace a cleaner, more resilient future.

2.2 Green upheaval: the new geopolitics of energy[1]

As the world accelerates its shift from fossil fuels to clean energy, a new set of geopolitical realities is emerging, reshaping global power, the nature of globalisation and the relationships between countries. Clean energy promises a future with far fewer harms from climate change, but this transition will also likely create new forms of competition and conflict, altering international relations and influencing the global economy in profound and unpredictable ways.

Fossil-fuel exporters, including Russia and Saudi Arabia, will continue to wield influence even as the world moves toward clean energy. As investments in fossil-fuel projects diminish in favour of green technologies, oil and gas supply may decline more rapidly than demand. This imbalance could create short-term energy shortages and heightened price volatility, strengthening the bargaining power of petrostates that hold spare capacity. These countries may benefit from increased revenue and strategic leverage in global energy markets during this turbulent period. While the end state of the transition might reduce their influence, the multi-decade period of transition will likely give traditional energy producers renewed geopolitical significance before their power wanes.

A clean-energy future will also introduce new sources of geopolitical influence. Countries with a competitive edge in clean-energy technologies, access to critical minerals and manufacturing capabilities will emerge as powerful players. China, in particular, dominates the production and refining of minerals essential for the energy transition, such as cobalt and lithium, which are crucial for electric vehicle batteries. This control over critical supply chains may provide China with a source of leverage at least for the next decade. In addition, the power to set standards for emerging technologies, from low-carbon fuels to digital tools managing electric grids, can confer influence on those able to establish global norms and specifications.

1 This section is based on Bordoff and O'Sullivan (2021).

Low-carbon fuels, such as hydrogen and ammonia, are poised to become strategically vital, particularly for decarbonising sectors that cannot rely solely on electricity, such as heavy industry and parts of transportation. The production of and trade in hydrogen, especially green hydrogen derived from renewable energy, will likely concentrate in regions with abundant resources. This concentration could lead to dependencies similar to today's reliance on natural gas. Some petrostates, such as the Gulf countries with ample solar potential, may successfully pivot to become 'electrostates', sustaining their influence as suppliers of hydrogen or ammonia.

While clean energy will play a transformative role, the transition is likely to push against the forces of globalisation. The decarbonisation process will depend heavily on electricity, a resource difficult to trade across borders compared to oil or gas. This shift may lead to a more regionalised energy system, with less global trade in energy. Additionally, clean energy technologies are already contributing to protectionist policies, as countries aim to reduce reliance on foreign supplies for critical components. The European Union's carbon border adjustment mechanism (CBAM) exemplifies how economic policies may begin penalising countries that lag in climate action, creating divisions within global trade networks.

The energy transition also poses unique challenges for developing countries, which currently rely on fossil fuels to meet their growth and development needs. As industrialised nations seek to rapidly decarbonise, they may pressure poorer nations to limit fossil-fuel use or abandon untapped hydrocarbon resources that offer revenue and growth. This disparity is likely to create friction between rich and poor countries, especially as wealthier countries continue to extract and consume fossil fuels while pressing others to move away from them. These imbalances could heighten global inequality, leading to resentment and geopolitical tension, especially if wealthier countries fail to fulfil financial promises made to help developing nations adapt to climate change and transition to clean energy.

A successful energy transition will require a more flexible approach to policy. For instance, strategic stockpiling of critical resources including natural gas, minerals and low-carbon fuels could help mitigate short-term disruptions. Policymakers should also maintain flexibility on energy sources and be prepared to keep some legacy fossil-fuel infrastructure in reserve, since there are many uncertainties about the demand outlook during a long period of transition.

Ultimately, while a fully decarbonised energy system may diminish the role of petrostates, stabilise electricity prices and reduce resource conflicts, the transition itself will not be smooth. The political and economic risks of this transformation are substantial. Without adequate planning and international cooperation, countries could face new security threats and economic disruptions. Recognising and addressing these emerging risks is essential for advancing climate goals while preserving global stability.

2.3 The new energy order: how governments will transform energy markets[2]

The Russian invasion of Ukraine has reshaped global energy priorities, placing energy security alongside climate goals at the forefront of national agendas. This shift will fundamentally alter the global energy system, leading to greater government intervention, increased nationalism and potentially a fractured global energy market. Unlike the oil crises of the 1970s, the energy crisis in 2022 was marked by an interconnected global economy with diverse energy sources and more robust distribution networks. However, the energy crisis triggered by Russia – and the disruption it caused not just in relation to natural gas but many energy sources – highlights significant vulnerabilities, especially in Europe, and has set the stage for a new era of energy policy dominated by state action.

The energy-security concerns that have arisen in response to

2 This section is based on Bordoff and O'Sullivan (2022).

the Ukraine crisis challenge the long-held belief that markets alone can provide reliable and affordable energy. With inflation spiking and supply chains strained, the need for a stable energy supply has become paramount. Reliance on market-driven solutions has left certain regions, especially Europe, exposed to geopolitical risks tied to fossil-fuel imports. Ensuring energy security requires strategic investments in infrastructure, such as terminals and pipelines. These are necessary to diversify energy supply and reduce dependence on suppliers like Russia. Private companies, however, often lack the incentives to invest in these security-driven projects due to their costly, long-term nature. Hence, as seen in Germany and Lithuania, which built infrastructure to secure liquefied natural gas (LNG) imports, governments are now stepping in to ensure that the infrastructure necessary for stable energy supplies is in place.

A notable parallel exists between today's crisis and the 1970s, when excessive government intervention exacerbated energy shortages. The current wave of state involvement, however, could be beneficial if managed prudently. Governments should be weary of heavy-handed price controls, as seen in past crises, which stifled market dynamics and led to shortages. Instead, a targeted approach to government involvement that addresses market failures is needed. Such an approach could include subsidies for developing renewable energy, strategic stockpiling and incentives to build adaptable infrastructure that can transition over time from fossil fuels to low-carbon alternatives.

In particular, governments must address three critical market failures:

- First, the private sector lacks incentives to build the infrastructure needed for both energy security and the transition to clean energy. For instance, Europe's vulnerability to Russian gas underscores the need for diversified infrastructure investments, which require state support.

- Second, the urgency of climate change means that new fossil-fuel investments may need to be retired early, discouraging private companies from financing these projects. Governments could designate certain projects as 'transition assets' and partially absorb costs, enabling infrastructure critical for today's energy needs while aligning with future climate objectives.
- Third, private firms and individuals do not bear the social costs of carbon emissions, so governments must enforce carbon pricing or mandates to curb emissions.

As Europe moves to reduce its reliance on Russian gas, other economies, notably in Asia, have increased coal production to meet their own energy needs. This shift complicates the global push for decarbonisation, illustrating how market pressures during a crisis can lead to setbacks for climate action. It is important, therefore, to coordinate international efforts, particularly in developing regions, where affordable clean energy is essential to achieve global climate goals. Institutions including the World Bank and the US Development Finance Corporation should provide financing mechanisms to facilitate clean-energy investments in these developing countries.

A more expansive role for government is necessary to balance the competing priorities of energy security and climate action. By carefully structuring interventions to address specific market failures, governments can foster stability and resilience in energy markets without replicating the mistakes of the 1970s. This approach would ensure that while markets remain a driving force, governments actively support the transition to a secure, low-carbon energy future. Failure to balance these imperatives could lead either to an energy-security crisis or severe climate consequences – or both.

2.4 The age of energy insecurity: how the fight for resources is upending geopolitics[3]

Energy security has never been more crucial, but it needs to be thought about it differently – beyond simply ensuring access to affordable supplies. Global energy markets are exposed to risks far more complicated than those during the oil crises of the 1970s. Russia's willingness to use its oil and gas resources as political weapons against Europe, slashing deliveries and sending prices soaring, is a reminder that energy remains a potent tool of geopolitical leverage. In response, European governments spent over €650 billion to protect their economies from the impacts (to mid-2023; Sgaravatti *et al*, 2023), showing just how vulnerable societies are to supply disruptions and how urgently a coordinated, strategic approach to energy security is needed.

The forces driving today's energy insecurity are clear: a renewed era of great-power rivalry, the reshaping of supply chains and the impact of climate change. The war in Ukraine starkly illustrates how the ambitions of a single leader can create an energy crisis that ripples across the world. At the same time, escalating competition between the US and China is reshaping supply chains, with many countries now striving to reduce their dependence on China for critical minerals and clean-energy technologies. While this strategy might reduce geopolitical risks, it also risks fragmenting global markets, which could complicate the energy transition.

The importance of diversification has not waned; it is just as relevant today as it was when Winston Churchill argued that security in oil lies *"in variety, and in variety alone"* after he transitioned the British Navy from coal to oil. While the clean-energy transition will eventually make energy sources more diverse, new vulnerabilities are also arising. Heavy reliance on a few countries, notably China, for the refining and processing of critical minerals exposes clean-energy supply chains to

3 This section is based on Bordoff and O'Sullivan (2023).

significant risks. To address this, the United States and its allies must forge new partnerships and trade agreements that create resilient, diverse supply chains.

Transitioning to a more electrified energy system presents further challenges. Wind and solar energy are inherently intermittent, and maintaining a stable grid requires storage and backup systems. As fossil-fuel plants that currently provide this flexibility are phased out, new mechanisms to ensure reliable electricity supply need to be developed. Solutions such as capacity markets that compensate generators for standing by, along with digital technologies that optimise energy use, can support grid resilience.

At the same time, care should be taken not to become too dependent on the concept of 'energy independence'. Interconnected energy markets remain important to energy security. While shocks may ripple through an integrated system, their impacts are typically less severe than in isolated markets. For example, following the Fukushima nuclear disaster in 2011, Japan was able to import other fuels to replace its lost nuclear power. As the clean-energy transition accelerates, the value of global trade in critical minerals and low-carbon fuels will need to expand significantly. Protectionist policies that seek to boost domestic production might fragment markets, increase costs and ultimately undermine energy security.

Climate change will also shape the future of energy security. Extreme weather events and shifting climate patterns are already placing pressure on both traditional and clean energy infrastructure. For example, droughts in California and Brazil have disrupted hydropower production, and such disruptions are likely to become more frequent as decarbonisation continues. Climate change could even affect the performance of renewable sources, as shifting wind patterns impact generation. Energy infrastructure must be adapted to withstand these stresses and support a secure, clean energy system.

Data transparency will also be critical for stable and efficient energy markets, much as it was in 1974, when the International Energy

Agency (IEA) was founded to provide reliable data on oil supplies. Today, a similar effort is needed for clean energy markets. Opacity can still lead to price volatility and supply disruptions in these markets. The IEA, for instance, is well-positioned to gather and disseminate data on critical minerals, and national regulators could work on improving transparency in trading and pricing.

Achieving energy security and climate goals will require a careful balance between government intervention and market forces. The mistakes of the 1970s, when excessive government control led to shortages and economic downturn, must be avoided. Instead, the focus should be on targeted intervention that addresses specific vulnerabilities, such as building strategic stockpiles of critical minerals and enhancing infrastructure resilience. By modernising the approach to energy security to reflect today's unique risks, modern economies can navigate the complex geopolitics of the energy transition and move toward a net-zero future without compromising stability.

2.5 Green peace: the fight against climate change can overcome geopolitical discord[4]

Despite the many risks, the clean-energy transition, if managed well, can address not only climate change but also some of today's most pressing geopolitical challenges. Although the push for clean energy has already started to reshape global politics, the journey toward a low-carbon future has its own risks.

Rising inflation, geopolitical conflicts and economic disruption have fuelled scepticism about clean energy. Some leaders now advocate for *"energy pragmatism"* or have called for a 'reality check' on the energy transition[5]. However, pulling back from this transition would be

4 This section is based on Bordoff and O'Sullivan (2024).

5 See for example Justin Worland, 'Dimon, Fink and the Rise of "Climate Pragmatism"', *Time*, 20 April 2024, https://time.com/6969442/dimon-fink-and-the-rise-of-climate-pragmatism/.

misguided. An accelerated clean-energy shift could address the geopolitical fractures and economic tensions that now threaten climate progress.

The energy transition's potential goes beyond simply reaching net-zero emissions by 2050. The energy system is deeply entwined with global politics, and reshaping it presents a unique opportunity to address both environmental and geopolitical issues. For instance, one might look to the success of the Marshall Plan, which not only rebuilt Europe after the Second World War but also strengthened alliances and stimulated economic stability. Similarly, an ambitious global energy transition could help reduce inequalities, stabilise supply chains, create economic opportunities and decrease reliance on one single country like China. This is a historic moment to pair climate goals with geopolitical objectives, making the transition a path toward global stability and prosperity.

Yet, transitioning economies are stuck in a negative feedback loop. Events including the COVID-19 pandemic, the Russian invasion of Ukraine and advances in technology have disrupted the international order. Economic fragmentation and great-power competition have intensified, slowing climate action. Competition with China, a major producer of clean-energy components, is a clear example of how geopolitical rivalry threatens progress. In response to security concerns, the US and Europe have imposed tariffs and restrictions on Chinese products, which could raise costs and slow the energy transition in the long term. At the same time, resentment is growing in the developing world, where leaders feel that wealthier countries, which historically contributed more to emissions, are not providing enough support for those facing climate impacts. Without stronger global support, political and economic divides between rich and poor countries could deepen, further complicating climate cooperation.

These challenges, however, are not insurmountable. An accelerated and inclusive energy transition could alleviate tensions, promoting both economic growth and geopolitical stability. Bridging the gap between developed and developing countries will be important, as lower-income countries hold tremendous potential for clean-energy production. Clean-energy investments in developing regions could also help address local economic needs and reduce reliance on traditional energy sources. For example, North Africa's solar capacity could support green-hydrogen production, a potential game-changer for low-carbon industrial processes. Developing these capacities could attract investment, create jobs and enhance global energy security, all at the same time.

To create a more stable global energy economy, protectionism should be reduced. While aimed at boosting clean energy, policies such as the US Inflation Reduction Act (IRA) and the EU's CBAM, also increase trade tensions and fragment markets. A better solution would involve expanding international cooperation and trade agreements for clean-energy components. Rather than blocking Chinese imports, the United States could work with a wider circle of partners to build resilient, diversified supply chains, supporting the transition without isolating a major player.

As the energy transition accelerates, a well-constructed carbon-pricing system could prevent further fragmentation. Border adjustments for carbon emissions, combined with domestic carbon taxes, could encourage other nations to adopt similar measures. This 'climate club' approach, in which participating countries align their carbon policies, would help level the playing field and prevent emissions-intensive activities from relocating to regions with weaker climate policies. Reforming global trade rules to support clean-energy development could further bolster international cooperation and make the transition more economically viable for all.

At the heart of this strategy is the recognition that the clean-energy transition does not have to escalate geopolitical rivalries. It can, in fact, become a tool to reduce conflict and promote peace. For example, the US and China, despite their competition, have found common ground on environmental protection and nuclear safety in the past. Continued cooperation in areas such as Arctic research, climate finance for developing countries and renewable energy could stabilise their relationship. The shared imperative to address climate change opens up channels for constructive engagement, even in a tense geopolitical climate.

The transition to clean energy is not merely a response to an environmental crisis but a generational opportunity to reshape global political and economic systems. The approach must be ambitious, not only in cutting emissions but also in crafting policies that promote a more just and stable world. A well-executed transition to a low-carbon economy could become a unifying force in an increasingly fragmented world, fostering collaboration, reducing tensions and paving the way for a prosperous and sustainable future.

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3 The climate trilemma

Ruud de Mooij and Vítor Gaspar[6]

3.1 Introduction

Governments face a climate policy trilemma, reflecting a three-way trade-off between (i) accommodating spending pressures to meet climate goals, (ii) respecting political red lines on taxation and (iii) preserving public debt sustainability and macroeconomic stability. Relying on public spending policies (through subsidies and green public investments) is the political path of least resistance but is also inefficient and fiscally unaffordable. Carbon pricing is more efficient and has the potential to improve fiscal outcomes but can trigger fierce political backlash. Scaling back climate ambitions relaxes both fiscal and political constraints but violates climate commitments and threatens runaway global warming. This article discusses the trilemma and elaborates on how it can be relaxed by a supplemental international coordination agreement on a minimum carbon price floor, which allows for flexible implementation and is linked to the global development agenda.

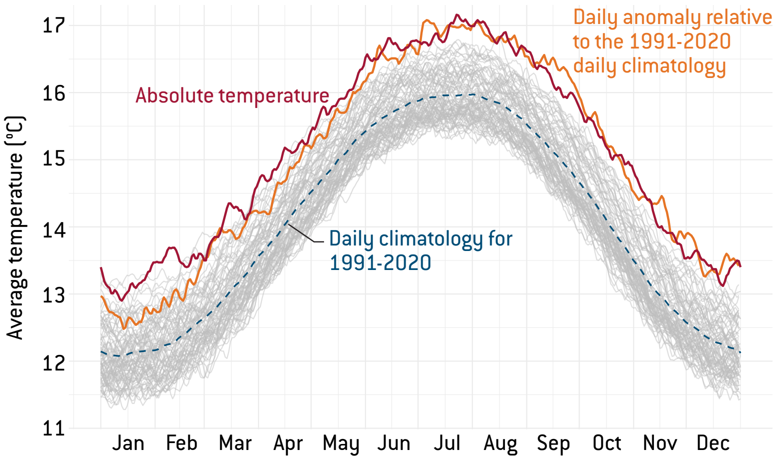
3.2 Achieving climate goals

Temperatures reached a new record high in 2024. On 22 July 2024, the global average surface temperature was 17.16 degrees Celsius,

6 The views expressed in this chapter are those of the authors and do not necessarily represent the views of the International Monetary Fund, its Executive Board or IMF management.

according to Copernicus data. This exceeded the previous record of 17.09°C, set just one day before, and 17.08°C on 6 July 2023. Now, 2024 has overtaken 2023 as the hottest year on record[7] (Figure 1). These new records, along with rising seawater temperatures, increased droughts and floods and more frequent extreme weather events, are tangible signs that global warming is accelerating. If unmitigated, the Intergovernmental Panel on Climate Change (IPCC, 2022) expects temperatures to increase by more than 3°C by 2100 compared to pre-industrial levels (as per IPCC scenario SSP2-4.5).

Figure 1: Daily global temperature



Source: ERA5 hourly data on single levels from 1940 to present, available at https://doi.org/10.24381/cds.adbb2d47.

Global warming will have negative economic implications. It is expected to reduce productivity in agriculture, fishing and work in non-climatised locations; lead to more frequent disruption of activity and destruction of productive capital due to extreme weather events,

7 See Copernicus, 'Global Climate Highlights 2024', *Copernicus*, 10 January 2025, available at https://climate.copernicus.eu/global-climate-highlights-2024

natural disasters and rising sea levels; divert resources to adaptation and reconstruction; increase morbidity and mortality due to more prevalent infectious diseases and natural disasters; and increase risks of migration and human conflict. No country is likely to remain unscathed, even if the worst warming impacts are initially concentrated in hotter regions.

A meta-analysis of existing studies on the economic cost by Tol (2024) suggested that global warming of 2.5°C comes with an average GDP reduction of 1.7 percent. Significant uncertainty around this number exists – with some studies even reporting positive effects for limited warming in some countries – with a distribution skewed towards more negative outcomes. There are significant differences between countries – with poorer and hotter countries being the most vulnerable to climate change.

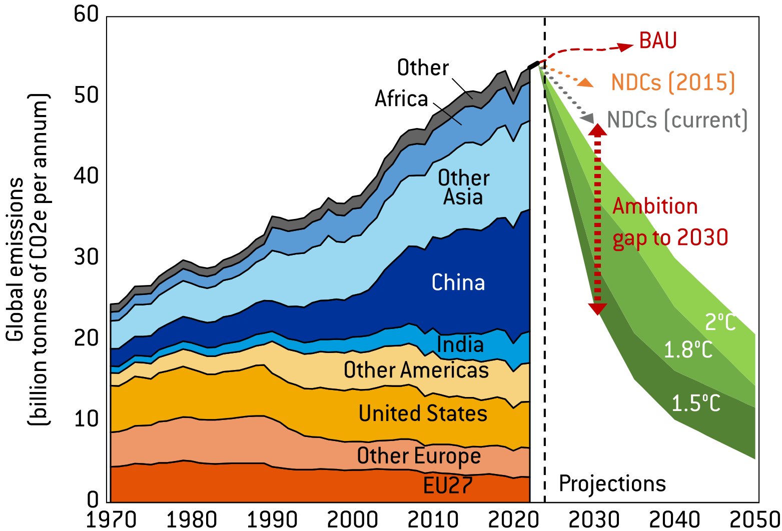
To mitigate global warming, it is essential to reduce greenhouse gas (GHG) emissions, notably carbon dioxide (75 percent of total GHGs) and methane (17 percent). Recognising this, countries agreed in 2015 in Paris to reduce GHG emissions to hold *"the increase in the global average temperature to well below 2°C above preindustrial levels"* (UNFCCC, 2015) and ideally to 1.5°C. To achieve this, countries defined nationally determined contributions (NDCs) for carbon, commonly defined as emission reduction targets to be met in or around 2030 relative to some benchmark. More recently, several countries have also committed to targets for zero net carbon emissions by around 2050 (ie a zero balance of gross carbon emissions and negative emissions from carbon sinks and through technology such as carbon capture and storage). Moreover, 158 countries have joined the global methane pledge to reduce global methane emissions by at least 30 percent by 2030 from 2020 levels. The rest of this paper will focus on carbon.

Unfortunately, despite progress in several countries, global CO_2 emissions are still rising. Going forward, there remain large ambition and implementation gaps for 2030 against the agreed temperature goals (Figure 2), and an enduring reduction in emissions has yet to materialise. Limiting global warming to 2°C requires cutting GHGs by 25 percent below 2019 levels by 2030, followed by a rapid decline to net zero emissions near the middle of this century.

The transition toward a cleaner energy mix will have to be extremely rapid. However, current NDCs fall short of this and imply an 11 percent reduction by 2030 – leaving a significant ambition gap. In some countries, targets are not, or are barely, binding, including in two of the three largest global emitters (China and India) (Figure 3).

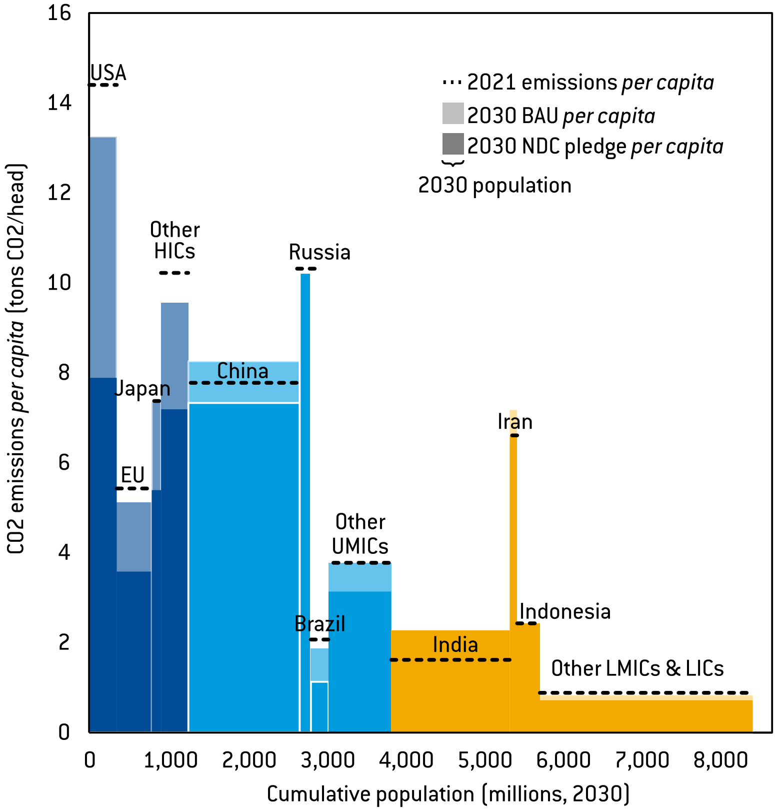
At the same time, countries vary in the extent to which existing and planned policies achieve economywide mitigation pledges in their NDCs (Black *et al,* 2023a). For instance, several G20 countries face significant implementation gaps in achieving their NDCs. Hence, we not only need more ambitious NDCs, but also stronger mitigation policies to achieve the existing NDCs.

Figure 2: Global emissions projections and pathways for warming targets



Source: Black *et al* (2024). Note: BAU = business as usual.

Figure 3: CO2 emissions *per capita* under BAU and NDC



Source: Black *et al* (2024). Note: HICs = high-income countries; UMICs = upper middle-income countries; LMICs = lower middle-income countries; LICs = low-income countries.

3.3 Fiscal sustainability

Achieving sufficient reductions in GHG emissions will require large investments in clean technology, such as in renewable energy, electrification, energy saving and carbon capture and storage. Estimates of the total global investment necessary to achieve carbon mitigation objectives vary widely but often run into trillions of US dollars. For instance, the International Energy Agency's *World Energy Outlook* (IEA, 2022) reported that global energy investment, currently estimated at $2 trillion, would more than double in a net zero scenario until 2050 – an increase of more than 2 percent of global GDP. An important question is: who will pay for this? Will private households and firms bear the brunt of these costs, incentivised by government regulations and policies? Or will the cost be borne collectively, with the public sector paying a significant share of it?

Can governments spend their way to net zero?

Some government spending will be necessary as part of any decarbonisation scenario. For example, there is a need to invest in green public infrastructure, such as pipelines for hydrogen and carbon capture and storage, high-voltage transmission lines to link sites for renewable plants and charging stations for electric vehicles. Also, public support for innovation is necessary in the form of basic research, subsidies for private research and development and support for deployment of existing low-carbon technology where market imperfections are important. The cost of these expenditures can be limited, and estimates suggests they could range between 0.2 to 0.3 percent of GDP per year during the transition toward net-zero emissions (De Mooij and Gaspar, 2024).

Yet, recent policy developments suggest that some governments are inclined to cover a much larger share of the costs of climate mitigation, notably by compensating households and firms for a significant portion of the required private investments through green subsidies and tax reliefs. For instance, the European Union has supplemented its emission trading scheme with a Green Deal Industrial Plan comprising tax breaks and relaxation of state aid (subsidy) rules in the coming years to boost renewable investment by the private sector. To compensate households for investments in buildings (such as heat pumps to replace fossil fuel heating systems), several European countries provide household subsidies for deployment of cleaner alternatives.

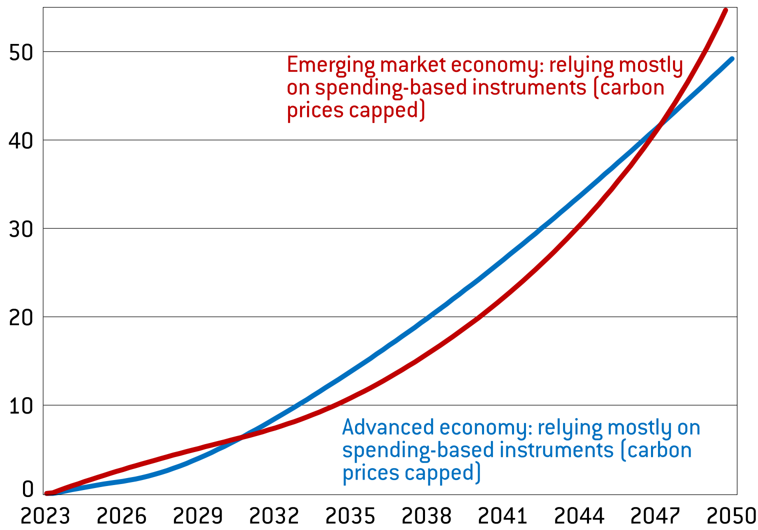
China has scaled up green public investment and subsidised the deployment of solar energy over the past decade under its Made in China 2025 initiative. An increasing number of countries, including Canada, Japan and Korea now provide subsidies for electric vehicles, batteries and renewable energy.

These spending policies are contentious because of various inefficiencies they might create (IMF, 2024). For instance, they may cause distortions in international markets; and they can create inefficiencies associated with government failures.

Moreover, these spending policies have important implications on public deficits and debts. The IMF's October 2023 *Fiscal Monitor* explored these fiscal implications in a scenario in which countries achieve their net zero emissions objective by 2050 by relying heavily on expenditure-based policy measures, thus scaling up recent policy efforts (IMF, 2023). Using a dynamic general equilibrium model, it presented the effects on debt dynamics up to 2050, for a representative advanced economy and a representative emerging market economy. In the model, the fiscal effects depend on how fiscal instruments affect not only the primary balance but also growth and interest rates. For instance, expenditure-based measures will support output in the short term but also raise deficits, interest rates and government borrowing costs.

For the representative advanced economy, the simulation considers a policy with a carbon price that rises to $75 per tonne by 2030 and remains at that level until 2050. Public investments and subsidies are scaled up to achieve the remaining emission reductions. If unfunded, the simulation shows that this policy package leads to a rise in the debt-to-GDP ratio by 45 percentage points by 2050, in part caused by increasing government borrowing costs (Figure 4). Hence, spending scale-ups will lead to debt levels that are unlikely to be sustainable. Figure 4 shows a similar increase for the representative emerging market economy.

Figure 4: Increase in public debt with expanded expenditure-based climate policies to achieve net zero emissions (% of GDP)



Source: IMF Fiscal Monitor, October 2023.

Similar studies have been conducted for the United Kingdom and France, using country-specific assumptions and models. The UK Office of Budget Responsibility (OBR, 2021) illustrated the fiscal implications of various scenarios for revenue and spending to achieve the country's net zero emissions goal by 2050. Key assumptions are made about carbon pricing, the loss of fuel excise revenue (ie whether it will be offset by a new charge on road use) and the government's support for insulation and heat pumps to decarbonise residential buildings. In OBR's central scenario (without a road user charge and with a 50 percent subsidy for decarbonisation of buildings), the debt-to-GDP ratio increased by 21 percent by 2050.

Similarly, Pisani-Ferry and Mahfouz (2023) explored debt dynamics for decarbonisation scenarios for revenue and spending policies in France. They also assumed that the government will provide significant support to households and firms to cover part of the decarbonisation investments, especially in buildings. In their central scenario, the debt-to-GDP ratio increased by 25 percent by 2040. About half of this increase is associated with public expenditure and another significant portion of the rise in debt results from the loss in tax revenue due to a slowdown in economic growth in their model.

The role of carbon pricing

Governments can use alternative pricing and non-pricing policies to incentivise private firms and households to achieve emission reduction targets. Non-pricing policies include standards and regulations, possibly applied to specific sectors such as industry, power, buildings, transport, forestry and extractives. Under these policies, the private sector would bear the cost of climate mitigation, such as switching to more expensive electric vehicles, heat pumps and renewable energy. The drawback of non-pricing policies, however, is that they might not achieve mitigation objectives in an efficient manner, ie at the lowest possible cost. Moreover, these policies do not raise public revenue as some carbon pricing instruments do, which could relax the fiscal constraint for governments.

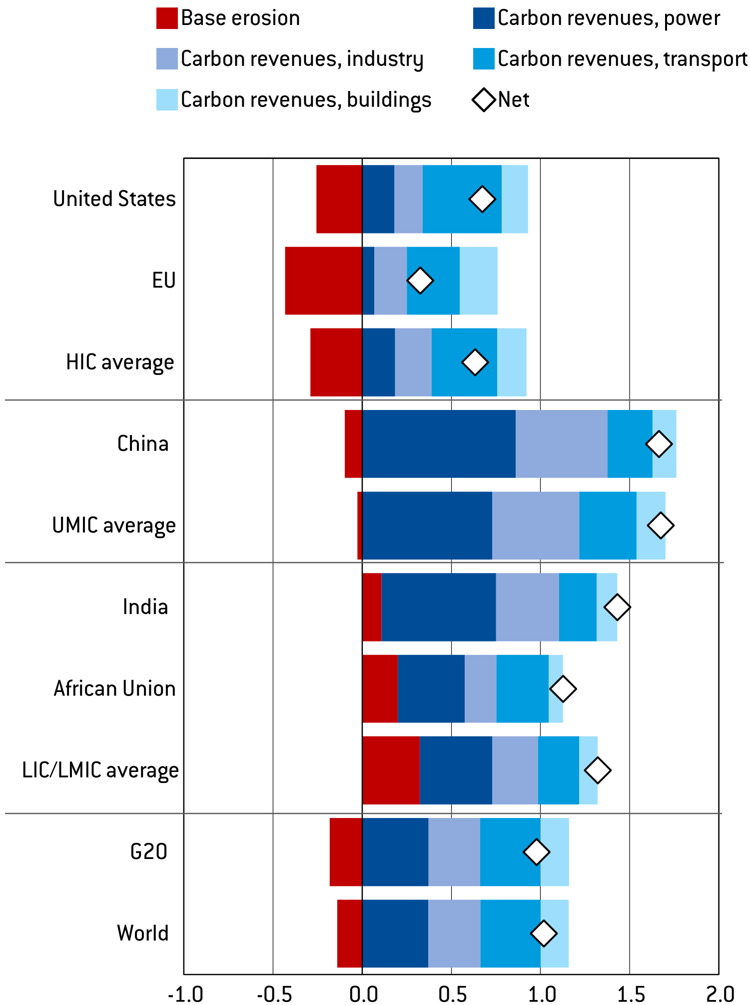
Carbon pricing internalises the external cost of carbon emissions in the behaviour of private agents, thus promoting the full range of responses for reducing emissions intensity, including through investment in clean technology, fuel substitution and energy saving. Aside from boosting the adoption of existing low-carbon technology, carbon prices also encourage the development of new clean technology. A uniform price of carbon implies that the marginal abatement cost of each alternative behavioural response to emission reduction is equal. This ensures that the policy is efficient as total abatement costs are minimised. This is not necessarily the case with regulations, subsidies or sectoral policies.

Carbon pricing can be implemented through a tax on the carbon content of fossil fuels or through an emission trading scheme, where permits can be auctioned and traded. Globally, there are 75 national, subnational and regional carbon pricing schemes in place, covering almost one quarter of global emissions (World Bank, 2024). The average price in these schemes is around $20/tonne of carbon. In Europe, the price per tonne of carbon in the emission trading scheme has varied from $60 to $100 in recent years.

Carbon pricing can raise significant amounts of public revenue, which could be used productively to contain the overall economic costs of decarbonisation. For instance, carbon tax revenues could provide a new source of funding for high-return public investments or for cutting distortionary taxes that harm incentives to work and invest. To illustrate the revenue potential from carbon pricing, Figure 5 shows results from simulating a carbon tax of $142/$84/$36 per tonne of carbon in, respectively, high, higher-middle and lower-middle and low-income countries, using the IMF/World Bank Climate Policy Assessment Tool (Black *et al,* 2023b). Such a scheme of carbon prices would reduce emissions enough to get on track to a 2°C warming scenario. The estimates capture the revenue effects of not only the carbon tax itself, but also from the base erosion of existing road fuel excises (due to the shift toward electric vehicles).

Figure 5 shows that net revenue from carbon pricing globally ranges between 1 and 1.5 percent of GDP in 2030. For high-income countries, this is notably less, especially in the European Union where net revenue will be low due to significant erosion of the existing fuel excise bases. In China and other high-middle-income countries, revenue is the highest at between 1.5 and 2 percent of GDP. In low- and lower-middle income countries, such as India and countries in the African Union, the revenue potential is between 1 and 1.5 percent of GDP.

Figure 5: Fiscal revenue impact of a carbon pricing scheme (% of 2030 GDP)



Source: Black *et al* (2024a). Note: assumes countries achieve more ambitious, 2°C-aligned NDCs mostly through carbon pricing (up to a maximum of $150 per tonne of CO2). Simple average carbon prices are $142, $84, and $36 per tonne, respectively in high, higher-middle and low and lower-middle countries.

3.4 Political constraints

In November 2018, the yellow-vest (*gilets jaunes*) movement in France organised massive protests against the government increasing a carbon-related fuel tax. The movement argued that a disproportionate burden of taxation was falling on the working and middle class and that the wealthiest people were able to escape taxation. They ultimately succeeded in delaying the introduction of the carbon tax. The case of France illustrates a more general pattern across countries of opposition against carbon taxes. An international survey across 28 countries by Dabla-Norris *et al* (2023) found that the key factor influencing public support for carbon pricing is its perceived effectiveness and fairness.

Effectiveness refers to the climate impact of the policy. This calls for using the revenue from carbon pricing for climate related spending, which is indeed what several countries do. For instance, over half of the revenue from existing carbon pricing schemes around the world is used to fund climate and nature-related programmes. The European Climate Law of 2021 (Regulation (EU) 2021/1119) requires EU countries to spend at least 50 percent of the auctioning revenue of the emission trading scheme for spending on climate and energy-related purposes, such as R&D, renewable energy development and improved energy efficiency.

Regarding fairness, policies tend to gain favour if they're seen as progressive. In most advanced economies, the effects of carbon pricing schemes on real household incomes tend to be slightly regressive or distribution neutral. Targeted measures through strengthening social transfer systems and lowering pre-existing taxes can offset these distributional effects and, in fact, potentially make the overall reform progressive. Revenue redistribution to low-income households or funding for health and education programmes can thus increases support for carbon pricing. Political resistance might thus be managed by designing and communicating careful policy packages that include compensation measures to support the most vulnerable households and most affected firms and workers.

Compensation schemes will need to be calibrated carefully to achieve a politically viable policy mix under carbon pricing. This may only require a fraction of the overall revenue from carbon pricing. For instance, if effective targeting of transfers to lower income groups is feasible, IMF analysis shows that compensating the three bottom income deciles of the income distribution would only require around 15 percent of the carbon tax revenue. Compensating the bottom half of households requires approximately 30 percent of revenue (De Mooij and Gaspar, 2024). Yet, some countries that introduced carbon pricing schemes have chosen to allocate a much larger fraction for compensation to manage the political constraints. For instance, Canada allocates all its revenue from carbon pricing through carbon dividends – which are akin to lump-sum payments to households.

A related – but different – issue relates to maintaining a level-playing field in international trade. By raising production costs for energy-intensive trade-exposed industries, carbon pricing could negatively affect competitiveness and cause a relocation of industries. This will induce carbon leakage – raising emissions elsewhere, which would reduce the effectiveness of carbon pricing.

To address such concerns, countries can use border carbon adjustments for energy-intensive trade-exposed industries to mitigate competitiveness effects (Keen *et al*, 2021). These are charges on embodied carbon in imports, potentially complemented by rebates for embodied carbon in domestic exports, to offset the impact of domestic carbon pricing. They level the playing field in domestic markets (for imports) and foreign markets (when rebates are provided on exports), mitigate carbon leakage effects and provide incentives for other countries to impose similar carbon prices (to pre-empt the impact of the border adjustment).

As carbon emissions are thus taxed on a destination basis – as opposed to an origin basis – they avoid production distortions (akin to the value added tax). Taxing carbon on a destination basis is more robust than the origin basis and leaves more scope for countries to exercise their domestic ambitions by setting higher carbon taxes without hurting competitiveness. Yet, border carbon adjustments need to be designed and administered carefully to be effective. The EU has introduced a border carbon adjustment scheme on imports (but no credit scheme for exports) for a selected number of energy-intensive sectors, which will come into full effect in 2026.

Climate policies also raise issues of intergenerational equity. Current generations are asked to incur a cost by investing in more expensive green technology to curb emissions and avoid damages for the benefit of future generations. If they are reluctant to do so, this can be reflected in political obstacles to the green transition. Transfers from future to current generations by raising government debt could make future generations pay for climate action and reduce current political opposition. Kotlikoff *et al* (2021) showed that a carbon tax that comes with well-designed intergenerational transfers can improve the welfare of both current and future generations while limiting the rise in global temperatures to 1.5°C. Yet, different views on intergenerational equity are possible. For instance, some may argue that future generations will already suffer from severe climate damage caused by past and current emissions and that imposing an additional public debt burden on them might be unfair.

3.5 Towards enhanced global action

Without further coordination, it will be difficult for individual countries to adequately scale up mitigation policies unilaterally in light of the global nature of the problem. For instance, individual countries are often concerned about the apparent lack of ambition in other countries and possible adverse effects of its own actions on competitiveness and carbon leakage. This can reduce political support for the domestic mitigation policies and explain the large gaps in climate ambition and implementation. Moreover, the lack of coordination will likely lead to greater emphasis on regulatory and subsidy approaches, which are fiscally unsustainable. It also implies less international support to finance clean energy transitions in developing countries.

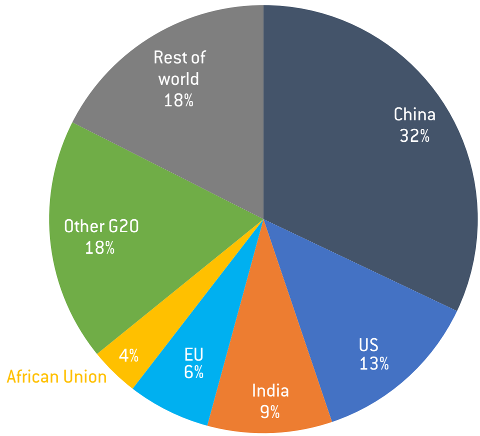
How could further global coordination ease the climate policy trilemma and help achieve the world's climate goals agreed in Paris, while managing fiscal and political constraints?

A global side agreement

Achieving the world's climate goals calls for a global side agreement to complement the Paris Agreement. As was well-known by negotiators at the time of drafting the Paris Agreement, the NDCs were unlikely to be sufficient to achieve the agreed temperature goals. A complementary side agreement to augment ambition would therefore be fully consistent with the aims of the Paris Agreement. It should help establish and sustain a more level playing field across countries and thus reduce the need for countries to take unilateral measures to maintain the competitiveness of industries in response to domestic climate action. A global deal would also mitigate concerns about carbon leakage, since all firms in energy-intensive trade-exposed industries would be affected by similar measures. Political support for effective and efficient carbon pricing might be stronger, as all participants realise that all would be made better off through the benefits from collective action.

A global side agreement should include at least the largest countries in the world. This includes large emerging market and developing countries, given their large and growing share of emissions (see Figure 6). It could involve the African Union (now a member of the G20) to have a better representation of low-income countries and establish a link with the global development agenda. This could pave the way for an agreement among the G20 that would cover over 80 percent of global emissions and subsequently for a full global agreement.

Figure 6: Projected contributions to global carbon emissions in 2030 with unchanged policies, by major emitter



Source: IMF CPAT-Tool; Sustainable Development Needs (2021); Global Carbon Budget (2021); Our World in Data (2022); International Energy Agency (2022) & IMF Staff Calculations. Note: Data uses fossil CO2 emissions from energy-related processes, excluding international aviation and maritime.

Coordination on price

Current NDCs are voluntary and defined in terms of quantities of national emission reductions. Reaching agreement over country-level emissions targets is difficult because there is no enforcement mechanism and there remains considerably uncertainty over the specific policy actions countries will undertake. For instance, few countries provide details on the means to achieve their NDC and there is no automatic mechanism ensuring targets are achieved.

A side agreement could be in the form of pricing instead of quantities. An example is the internationally agreed carbon price floor, as proposed earlier by IMF staff (Parry *et al*, 2021). It provides for an effective coordination mechanism for catalysing the needed global action by focusing on a minimum carbon price that each participating country must put on their carbon emissions. Negotiations based on a minimum price level would be transparent and will focus policy efforts on the means to achieve the emissions cuts, rather than on abstract ambition levels. The focus on price floors, rather than price levels, accommodates countries needing to exceed the floor price to meet their Paris mitigation pledges.

Provisions for flexibility will be necessary to address equity concerns and potential political obstacles to carbon pricing. Lower price floor requirements for developing economies will be appropriate and needed to encourage their participation, given their lower *per-capita* income, smaller contribution to historical emissions and generally higher emissions intensity of production. While explicit carbon prices through taxation or an emission trading scheme would be most efficient to achieve emission reductions, alternative measures could also be used by countries, such as feebates, standards, regulations, or subsidies. Allowing these alternative approaches that yield equivalent emission reductions will accommodate countries for whom, due to domestic political or other factors, standard carbon pricing instruments are difficult to implement or increase.

If the agreement allows for the adoption of equivalent non-pricing policies, a methodology is required for computing carbon prices associated with alternative non-pricing policies. This could be done through measuring emissions impacts and/or their carbon price equivalent: the (shadow) carbon price that would yield the same emissions reduction as non-pricing policies. The methodology needs to avoid double counting of emissions reductions where policies overlap (for example, where the power sector is subject to both carbon pricing and renewables policies).

Black *et al* (2022) developed such a methodology, deriving the shadow price per tonne of carbon associated with alternative policies of emission reduction, using the IMF/World Bank Climate Policy Assessment Tool . A commonly agreed methodology for calculating price equivalencies of alternative policies is important to monitor compliance with the internationally agreed carbon price floor.

Discretionary adjustment of price floors might be needed if it turns out that collective emissions are not on track to meet the common climate ambition.

Climate and development

Any side agreement on climate mitigation should pay due attention to international equity issues – beyond differentiation in the price floor itself. For developing countries, the agreement will have to be compatible with both energy access and the Sustainable Development Goals. The transition to a low-carbon economy might be costly for developing countries with rapidly growing energy demand and fiscal and financial constraints that limit funding for green public investments or domestic compensation measures. The side agreement may require side payments in the form of financial and technological transfers from advanced economies and/or through revenue sharing of the globally agreed minimum carbon price. For instance, Raghuram Rajan suggested a revenue-sharing scheme that is based on an equal *per-capita* assignment of property rights to access the global common[8]. If climate externalities are efficiently internalised through a globally agreed price floor, the resulting revenue should then be distributed across the global population on a *per-capita* basis to reflect this equal distribution of property rights. If carbon prices are initially collected by individual countries based on their own origin-based emissions, poor countries should be compensated by rich countries through fiscal transfers determined by the difference between a country's own emissions *per capita* and the world average: countries with emissions *per capita* below the global average (usually poor countries) would thus be net receivers, while countries with higher emissions *per capita* (usually rich countries) will be net payers.

8 Raghuram G. Rajan, 'A Global Incentive to Reduce Emissions,' *Project Syndicate*, 13 May 2021, available at https://www.project-syndicate.org/commentary/global-carbon-incentive-for-reducing-emissions-by-raghuram-rajan-2021-05.

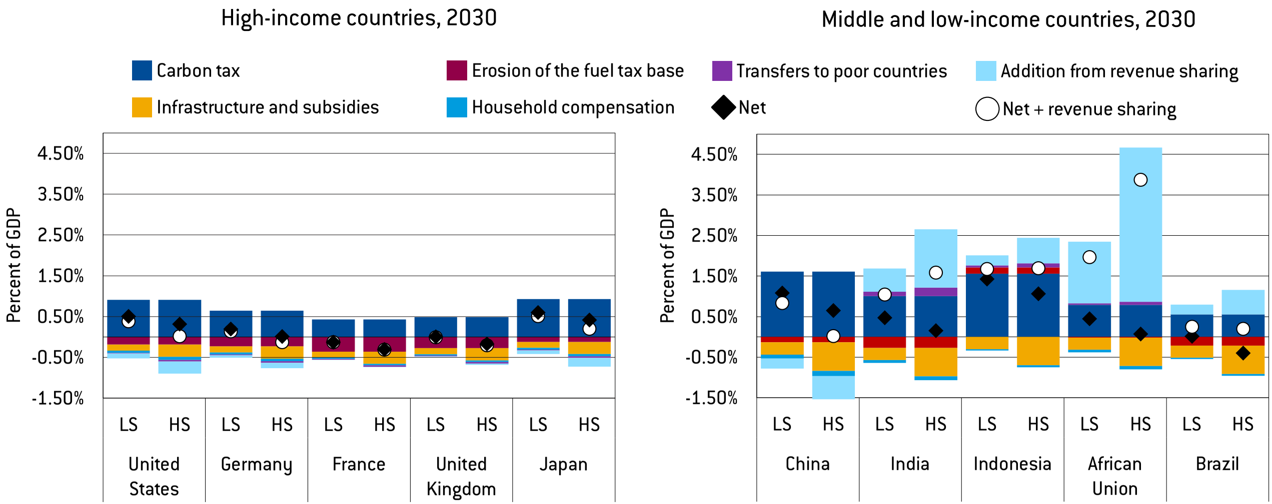
De Mooij and Gaspar (2024) simulated the magnitude of these transfers under a $25 per tonne minimum carbon price in 2030 and found that approximately $230 billion would be transferred to the African Union and India, while net payments would come from China, the EU and the US. While such a scenario is merely illustrative and other possibilities exist, it makes clear how climate policy can be linked to sustainable development.

Revenue sharing is perhaps most salient for carbon pricing in international shipping and aviation. Both sectors will ultimately require some form of pricing schemes to level the playing field for investments in zero-emission fuels. Carbon pricing aligned with a net zero emissions pathway could raise considerable revenue, estimated by Black *et al* (2024b) at around $200 billion a year by 2035. Revenue could be used for several purposes, including to support R&D in the international transportation sector, to compensate vulnerable states affected by higher transportation costs, or as remittances to national governments. As it is not straightforward to establish which countries should claim the taxing rights from international transportation (the country of origin, destination, residence, or transit), there is salience in allocating at least a portion of the revenue for climate finance to developing countries.

Net fiscal impact

An international side agreement on a carbon price floor might make it politically more acceptable to adopt an explicit carbon price – given that it maintains a level playing field relative to other countries. Thus, it can reconcile climate objectives with fiscal sustainability. De Mooij and Gaspar (2024) explored the net fiscal impact of global climate action if countries adopt a package that combines carbon pricing, compensation for low-income households, green public spending and revenue-sharing with developing countries (Figure 7).

Figure 7: Net fiscal impact of global climate mitigation packages based on carbon pricing and climate spending



Note: LS = low-spending scenario; HS = high-spending scenario. LS assumes additional spending on infrastructure and subsidies by 0.15 percent of GDP in advanced economies and 0.3 percent in emerging and developing economies; transfers compensate the bottom 3 deciles (0.15 percent of carbon revenue), and revenue sharing of $10 carbon price. HS assumes additional spending on infrastructure and subsidies by 0.3 percent in advanced economies and 0.7 percent in emerging market and developing economies; transfers compensate bottom 5 deciles (0.3 percent of carbon revenues), and revenue sharing of $25 carbon price.

For European countries, they find that the net revenue from carbon pricing and fuel taxes will be insufficient to cover higher spending. Hence, European countries see their debt rise moderately or they need to raise other taxes, such as road-user charges, to offset the negative effects on the primary balance. In the United States and Japan, revenue gains are around 1 percent of GDP – higher than in Europe because of the higher carbon intensity of the two countries' GDP and lower existing fuel excises. This exceeds additional spending needs. Hence, the positive fiscal balance in these countries allows them to reduce existing taxes as part of a revenue-neutral reform or reduce their public debt. Revenue gains exceed 2 percent of GDP in China and India and are around 1.5 percent of GDP in the African Union and Brazil. This typically exceeds the additional expenditures so that these countries could support the wider development agenda, for example for adaptation investment or other sustainable development goals.

3.6 Conclusion

This chapter has discussed the three-way trade-off that countries face when unilaterally managing their climate transition, involving choices of meeting their climate policy objectives, maintaining debt sustainability and respecting political constraints. High climate spending, recently pursued in several advanced economies through subsidies and public investment programmes, can support a country's climate goals while avoiding political resistance, but such a scenario is likely fiscally unsustainable and inefficient. In contrast, relying primarily on carbon pricing will produce favourable fiscal outcomes and achieve carbon mitigation in an efficient manner. But carbon pricing can be unpopular, and this scenario could thus cross political red lines. Scaling back climate ambition could relax both fiscal and political constraints but would violate climate commitments.

Countries can better navigate this policy trilemma if they agreed on an international side-deal to the Paris Agreement, which maintains a level playing field across countries and addresses concerns about competitiveness, relocation of industries and carbon leakage. The international agreement could be initiated by the largest economies and subsequently adopted globally. If pursued through an international carbon price floor, coordination would be transparent, allow for flexibility in the choice of policy instruments and would enable linking climate policies to the global development agenda.

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4 Industrial policy for competitiveness in the energy transition

Ketan Ahuja and Ricardo Hausmann

4.1 Introduction

Solar panels have become astoundingly cheap. At $0.10 per watt, a solar panel now costs about as much as six lattes, a nice meal out or a bicycle helmet[9]. As recently as 2017, solar panels cost ten times as much[10]. Few serious observers predicted that solar panels would come down in cost so quickly[11].

A common view among economic policymakers is that markets should be trusted to pick winners through organic market competition, and policy should make markets work better by removing distortions and correcting for failures. But organic market processes have had very little to do with the forces driving the falling cost of solar,

9 Emiliano Bellini 'Solar Module Prices May Reach $0.10/W by End 2024,' *pv magazine*, 23 November 2023, https://www.pv-magazine.com/2023/11/23/solar-module-prices-may-reach-0-10-w-by-end-2024/. Assuming a 400W module, a solar panel would cost around $40.

10 See Solar Energy Technologies Office, 'The SunShot Initiative,' undated, https://www.energy.gov/eere/solar/sunshot-initiative.

11 Uwe Dahlmeier, 'Empirical Approach Shows PV Is Getting Cheaper than All the Forecasters Expect,' *pv magazine*, 5 December 2023, https://www.pv-magazine.com/2023/12/05/empirical-approach-shows-pv-is-getting-cheaper-than-all-the-forecasters-expect/.

or of other technologies including batteries, electric vehicles, wind power and a host of other technologies. These cost reductions have instead come from state-directed goals, engineered market structures and policy-driven scaling of supply and demand under conditions of intense competition, largely in China, with China building an unassailable lead in solar manufacturing in the process.

China's experience in solar manufacturing changes thinking about competitiveness, industrial policy and competition policy in several ways. It leads to an understanding that states have a role in shaping competitiveness above and beyond organic market processes, through shaping supply, demand and market conditions. It also demonstrates that industrial policy and competition policy are intrinsically related and mutually enhancing. Finally, it shows that companies become big by being competitive; they should not be made big so that they can become competitive. Rather than create national champions through 'grand projects' or permissive merger policy, industrial policy should instead aim to make companies good rather than big, by combining the right support with engineered competitive market conditions.

4.2 How China's industrial policy built competitiveness in solar manufacturing

Scientists and industrialists in the US, Europe, Japan and Australia invented the main technologies needed to commercialise solar panels, and led solar manufacturing until the mid-2000s. Scientists at Bell Labs in the US invented the solar panel in 1954, and US industrialists invented many of the other main architectural features of solar panels in the following decades, such as glass casing and screen printing of solar cells on silicon wafers, supported by modest US federal government investments in research (Jones and Bouamane, 2012). Initial manufacturing arose to satisfy niche markets including powering satellites, offshore oil platforms and calculators. By the late 1970s, solar costs had come down from $500/watt in satellite systems to $6/watt, making some off-grid terrestrial power applications commercially viable (Jones and Bouamane, 2012).

This emerging commercial viability, the oil crises of the 1970s and the Carter administration's $3 billion investment in solar energy research and tax credits for deployment, induced a wave of entry into solar manufacturing in the US. Some US states, such as California, supplemented this support with their own tax credits for deployment of solar. But most of these startups went bankrupt in the 1980s because of declining oil prices and withdrawal by President Reagan and California Governor Jerry Brown of policy support for solar. German and Japanese manufacturers bought many of these American startups and their technology out of bankruptcy, as interest in solar energy grew in Germany and Japan (Jones and Bouamane, 2012).

Solar manufacturing began picking up steam again when German municipal governments began subsidising deployment of rooftop solar through municipal electric utilities in the 1990s. Japan, California and other states copied these demand-side subsidies, and by the early 2000s solar deployments were growing by 25 percent annually. This induced substantial entry by private sector manufacturers and as late as 2006, German and Japanese manufacturers dominated solar PV manufacturing (Jones and Bouamane, 2012).

But China began a concentrated push into solar manufacturing in the early 2000s, with substantial policy support from 2003 for scaling manufacturing (Zhi *et al*, 2014). China's solar manufacturing capacity roughly tripled every year from 2003 to 2008. By 2011 Chinese firms dominated global solar production (Jones and Bouamane, 2012).

China's solar manufacturing efforts involved Chinese provinces, state-owned banks and municipalities shoveling money into solar manufacturers and the solar supply chain, creating substantial overcapacity in the sector and forcing its manufacturers into brutal competitive trials, which fed rapid cycles of innovation and cost-cutting[12].

12 Jonas Nahm, 'How Solar Developed from the Bottom-Up in China', *IGCC Blog*, 14 March 2023, UC Institute on Global Conflict and Cooperation, https://ucigcc.org/blog/how-solar-developed-from-the-bottom-up-in-china/.

Huge sums were involved: of the $41.8 billion invested in the global solar industry in 2010, $33.7 billion came from the Chinese government (Zhang *et al*, 2013). These market conditions led manufacturers to expand output even as they made losses, in a bid for economies of scale and lower unit costs[13]. They also led to operational innovations to squeeze all possible costs out of production: one practice among leading solar manufacturers in China is to receive deliveries of components to their factories every twelve hours (sometimes by automated rail cars) to avoid holding extra inventory and to keep hold of cash[14].

These investments extended along the supply chain, generating capacity and competitive pressure and commoditising inputs into solar panels in ways that drove down costs all along the solar value chain (Zhang *et al*, 2021). To get suppliers to scale up production, original equipment manufacturers (OEMs) often need to commit to buy their suppliers' increased capacity at an attractive price for several years. Industrial policy investments along the supply chain turned the tables on suppliers, leading them to compete hard with each other for OEMs' orderbooks, and commoditising inputs into panels. With this market structure, solar OEMs could adopt procurement practices such as renegotiating their supply contracts for inputs every three months, switching suppliers often and buying only 80 percent of their needs through long-term contracts (while picking up the remaining 20 percent whenever spot market prices were low) (Zhi *et al*, 2014).

China accompanied these supply-side investments with a strong demand-pull, with incentives and targets to promote installation of panels (Zhi *et al*, 2014), solving coordination problems around integrating solar into electric grids along the way (Zhang *et al*,

13 See, for example, Simon Yuen, 'Three Major Chinese PV Manufacturers Report Losses in H1 2024', PV Tech, 11 July 2024, https://www.pv-tech.org/major-chinese-solar-manufacturers-report-losses-in-h1-2024-due-to-increased-competition/.

14 We understand this is the case from conversations with executives in solar manufacturing.

2013). Domestic deployment targets modulated with international demand, increasing when global demand for panels softened during the great recession, to provide stable and growing demand for solar manufacturers[15].

Such intense competitive pressure can force companies to compete on price rather than quality, and lead to quality erosion (Ezrachi and Stucke, 2015). But China's industrial policy incentivised quality upgrading through a top-runner programme (announced in 2015) (Tan, 2017). This programme conditioned access to government-subsidised projects on meeting objective quality and performance standards that ratchetted up each year. Tax rules also allowed solar OEMs to rapidly depreciate equipment used on solar manufacturing lines, allowing manufacturers to quickly reconfigure their manufacturing lines as new technology came out[16]. This enabled manufacturers to quickly scale up production of the most advanced panels, speeding-up cycles of innovation.

While funding research and innovation was central to industrial policy in the US, Japan and Germany, it was less important in China's efforts to compete on quality (Zhi *et al*, 2014): Chinese manufacturers initially gained technology leadership by hiring leading foreign scientists and engineers, purchasing manufacturing equipment from foreign suppliers and buying technologically advanced western manufacturers (like Q-Cells) out of bankruptcy (Jones and Bouamane, 2012).

Faced with this competition, solar manufacturers operate with razor-thin margins, and frequently make losses[17]. The promise made by

15 Jonas Nahm, 'How Solar Developed from the Bottom-Up in China,' *IGCC Blog*, 14 March 2023, UC Institute on Global Conflict and Cooperation, https://ucigcc.org/blog/how-solar-developed-from-the-bottom-up-in-china/.

16 We understand this is the case from conversations with solar manufacturing OEMs.

17 Andrew Hayley, 'China Solar Industry Faces Shakeout, but Rock-Bottom Prices to Persist,' *Reuters*, 3 April 2024, https://www.reuters.com/business/energy/china-solar-industry-faces-shakeout-rock-bottom-prices-persist-2024-04-03/.

Chinese government entities to their solar manufacturers is tacit: they're willing to tolerate bankruptcies and losses within the sector[18], but will ensure that the top performers remain viable, by extending low-cost loans and other support as needed[19]. The Chinese government also encourages consolidation and industry restructuring when supply chain sectors face persistent losses (Zhang *et al*, 2013).

None of this is to suggest that China's industrial policy in solar is centrally planned, surgical or particularly efficient. More than 300 provincial governments and municipalities have supported development of over 2,000 companies in China's solar value chain, within broad parameters set at national level, often supporting their own local manufacturers as far as they can (Zhang *et al*, 2013). China's industrial policy leverages this inter-regional competition, in the process decentralising decision-making. This can be enormously wasteful, but it is effective in consistently producing competitive industrial conglomerates[20].

This history makes three things clear. First, the great solar cost curve has been anything but organic. It has involved active state intervention to shape supply and demand and to engineer conditions of competition, with many different levels and forms of support from state-owned banks and government agencies. China's comparative advantage in solar was built, not innate.

Second, regional, municipal and state governments played leading roles in driving policy support for solar, from initial demand subsidies in California and by German municipal utilities, to supply-side

18 Keith Bradsher, 'China Rules Solar Energy, but Its Industry at Home Is in Trouble', *The New York Times*, 25 July 2024, https://www.nytimes.com/2024/07/25/business/china-solar-energy.html.

19 Ali Imran Naqvi, 'Solar Industry Faces Collapse amid Surplus and Plunging Prices', *pv magazine*, 28 August 2024, https://www.pv-magazine-india.com/2024/08/28/solar-industry-faces-collapse-amid-surplus-and-plunging-prices/.

20 Patricia Cohen, Keith Bradsher, and Jim Tankersley, 'How China Pulled So Far Ahead on Industrial Policy', *The New York Times*, 27 May 2024, https://www.nytimes.com/2024/05/27/business/economy/china-us-tariffs.html.

investments by Chinese provinces and municipalities. Industrial policy in solar involved many state actors and leveraged regional initiative and interregional competition, in a way that was adaptive and self-organising, rather than centrally planned.

Third, competition has been a central feature of this industrial policy: policy helped shape highly competitive market structures that drove cost cutting and innovation. This has implications for how to think about the role of industrial and competition policy in driving competitiveness.

4.3 Industrial policy for competitiveness

Like furniture, industrial policy comes in many shapes and sizes. Just as 'furniture' can refer to a sofa, table, bed or chair, 'industrial policy' has many different forms that pursue different goals using different policy instruments.

Our focus is a specific type of industrial policy that we term 'industrial policy for competitiveness'. Industrial policy for competitiveness involves policy to take or protect commercial leadership in an existing, internationally competitive industry, for example through supporting and scaling production, shaping market structures and leveraging trade relationships.

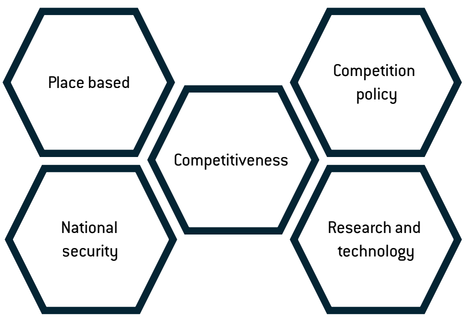
Governments may use industrial policy to shape the structure of industry in different ways and for different purposes (Juhász *et al*, 2023). One common form of industrial policy supports commercialisation of new technologies. Policy instruments for technology commercialisation include funding R&D, facilitating partnerships between companies and research labs, supporting technology transfer and funding pilots, demonstration and deployment of new technologies. Europe and the US have long recognised the importance of this form of industrial policy, and they practice it successfully with tools such as the US' Advanced Research Projects Agency (ARPA) model, and the EU's Horizon research programme.

Industrial policy has also often supported national security goals through, for example, procurement in defence and aerospace, maintaining redundant production capacity for critical technology, even at very high cost, and securing supply chains. These policy instruments often do not aim to create commercial leadership in a sector; they instead aim to equip military forces and protect supply chains, critical infrastructure and technology from disruption from a potential foreign adversary.

Place-based industrial policy is going through a resurgence in popularity: this form of industrial policy aims to stimulate, revive and drive growth in different regions within a country. Place-based industrial policy may spread economic prosperity more broadly, address local binding constraints or support regional diversification and economic development. The EU's smart specialisation initiative represents a form of place-based industrial policy.

While not always considered a domain of industrial policy, competition policy and antitrust involve state intervention to shape market structure by regulating cartels, mergers and monopolies. A common understanding of competition policy is that it exists to make markets function better for consumers.

Figure 1: Different forms of industrial policy



These different forms of industrial policy are not strictly separate or delineated from each other. They can be mutually supportive and enhancing. Policy to promote research and development or technology commercialisation can improve a nation's industrial competitiveness. Place-based policy and industrial policy to promote national security can support thriving regional industrial clusters, and thereby enhance a country's economic structure, capabilities and diversification. Efforts to support national competitiveness in certain industries can, if successful, enhance national security, revitalise struggling regions and benefit consumers through enhanced competition.

But these different forms of industrial policy do each have their own dominant tactics, policy instruments and institutional 'flavour'.

China's experience of promoting solar manufacturing illustrates the policy instruments, tactics and 'flavours' of industrial policy for competitiveness: supporting the creation and scaling of high-quality domestic suppliers with funding, promoting technology adoption and upgrading, creating a demand 'pull', engineering competitive market structures and supporting reduction of unit costs and buildout of a strong supply chain.

4.4 The economic rationale for industrial policy for competitiveness

Industrial policy for competitiveness is built around addressing a number of specific, well-known market failures. Many industrial and manufacturing sectors exhibit increasing returns in production such as large economies of scale, learning curves and positive externalities. The literature on infant industry protection has long recognised that these market failures can warrant industrial policy intervention, such as subsidies, demand guarantees and trade protection, to help a domestic industry learn and reach competitive scale.

Coordination problems can often arise to inhibit adoption of new technology. For solar (and other energy technologies), these coordination problems can involve complexities around grid installation and infrastructure readiness, permits and workforce training, as well as hold-up problems along the supply chain. Government intervention can correct these market failures and allow for demand to scale quickly as costs decline.

Hold up problems can often arise as supply chains develop. To begin production in a supply chain, a firm must make product- or relationship-specific investments that can leave it dependent on a particular company or set of companies. A solar glass manufacturer, for example, must invest in machinery and production processes that enable it to produce a product of certain size and specifications, and may not be able to retool for other customer segments quickly or cheaply. Industrial policy investments that create competition along the supply chain can help solve this market failure, by standardising inputs and giving buyers and sellers multiple options, which makes it easier for buyers and sellers to switch trading partners, reduces the bargaining power of sellers and increases competitive pressure on sellers. This was effective in China's solar manufacturing policy, creating competitive market structures for inputs such as glass coverings for panels. These market structures enabled Chinese OEMs to adopt procurement practices such as retendering for supply every three months and procuring substantial amounts of their supply on the spot-market when prices are low.

Private investors may underinvest in capacity where externalities prevent them from fully privatising returns, where their risk tolerance is greater than that of their society, where they do not have the depth of capital to commit to large investments with very long time horizons, or where a very competitive market structure reduces a private investor's ability to appropriate profits. All these features are present in solar manufacturing.

In markets where quality is hard for customers to assess and where price competition is severe, competition may lead to quality erosion (Ezrachi and Stucke, 2015). Industrial policy can have a valid role in promoting quality upgrading in these circumstances, such as in China's top-runner programme.

4.5 Institutions and ideology around industrial policy

The discussion above demonstrates that industrial policy for competitiveness can be economically sound because many market failures are always present and addressing each one with a separate instrument may not be feasible or even practical. In particular, the process of building out supply chains and capacity in an expanding industry is rife with market failures. China has used this realisation to build competitiveness in solar manufacturing and a host of other industries, such as electric cars[21], batteries, wind and electrolysers[22].

And yet, in the US and Europe, the tendency is to think that it can be left to organic market competition to pick winners, leverage innate comparative advantages and determine competitiveness in different industries. Western economic policymakers have treated the exhortation to only intervene to correct market failures as a reason to be sceptical about intervention, rather than a call to go looking for market failures to correct.

It is worth questioning whether a paradigm that the government should only intervene to correct market failures has been helpful in guiding thinking: while it imposes discipline, it articulates a default of non-intervention. An alternative paradigm, that government has a role in supporting buildout of strategic industries by solving constraints that arise and employing market mechanisms to build competitiveness, could impose similar discipline while articulating a more active (yet still economically sound) role for the state in building competitiveness.

China's success in solar shows that developing competitiveness in the

21 Keith Bradsher, 'China's Electric Cars Keep Improving, a Worry for Rivals Elsewhere', *The New York Times*, 1 May 2024, https://www.nytimes.com/2024/05/01/business/china-electric-vehicles.html.

22 Patricia Cohen, Keith Bradsher, and Jim Tankersley, 'How China Pulled So Far Ahead on Industrial Policy', *The New York Times*, 27 May 2024, https://www.nytimes.com/2024/05/27/business/economy/china-us-tariffs.html; Keith Bradsher, 'What to Know About China's Export Dominance', *The New York Times*, 19 April 2024, https://www.nytimes.com/2024/04/19/business/china-exports.html.

industries of the future can depend on how supportive a country's institutions and ideas around industrial policy are. Because policymakers in the US and Europe tend to think that organic market processes should determine competitiveness, the US and Europe have not sufficiently developed the institutions, capacity and policy playbooks to engage effectively in industrial policy for competitiveness.

In the US, for example, industrial policy has focused on technology commercialisation and national security. The US' strong institutions that support technology commercialisation make it among the best places in the world to develop and commercialise a new technology. It has a strong research ecosystem, consisting of first-class universities and national labs, effective technology transfer programmes such as SBIR and STTR, and far-sighted, mission-driven agencies such as DARPA and ARPA-E[23]. All of these support a thriving private venture capital ecosystem. There is broadly shared support for these activities, based on the economic rationale that the limited appropriability of technology, and positive spillovers to research, mean the private sector will underinvest in research and development.

But US institutions that help in the development of international competitiveness in commercially existing industries are relatively weak. Guided by the sense that government should not pick winners and organic market competition should instead determine competitiveness, the US has less experience with the tools of industrial policy for competitiveness – strategically promoting investment along a supply chain, stimulating demand, structuring markets to shape competition and solving coordination problems. Even though these actions each have an economic rationale that is tied to market failures, they have tended not to be seen as a legitimate domain for government industrial policy.

Where the US government has historically invested in scaling manufacturing capacity and supporting demand, it has tended to do so

23 SBIR stands for Small Business Innovation Research, STTR = Small Business Technology Transfer, DARPA = Defense Advanced Research Projects Agency, and ARPA-E = Advanced Research Projects Agency-Energy.

to commercialise new technologies rather build competitiveness. Even then, these activities have been controversial. The US Department of Energy's large loans to Solyndra and Tesla in 2009 and 2010 to support manufacturing facilities supported technologies that were new to market. But Solyndra's failure led the Department of Energy to retrench from these types of loans, amid accusations that it was picking winners[24]. In domains other than energy technologies, the US government has occasionally supported emergence of new competitors with coordinated supply and demand investments, for example in creating a domestic commercial space launch market (with SpaceX), or in bringing a commercial MRNA covid vaccine to market (with Operation Warp Speed). But national security and public health needs justified these policies, rather than a desire to promote industrial competitiveness.

US states have sometimes had more latitude to engage in industrial policy for competitiveness. Massachusetts Governor Deval Patrick's Life Sciences Act in 2008 invested $1 billion to increase the competitiveness of Boston's life sciences industry through capital investments, tax incentives to support manufacturing and commercialisation, and workforce training[25].

Competition policy enforcers in the US have until recently adopted a similar guiding ideology: that the role of competition policy is to make markets work better for consumers by intervening when cartels, mergers and monopolies might harm consumers. Competition policy has, from this perspective, been a relatively separate policy instrument that exists to correct for specific, known harms, rather than part of broader national industrial policy to structure markets in ways that promote national competitiveness.

24 Jeff Brady, 'After Solyndra Loss, U.S. Energy Loan Program Turning A Profit,' *NPR*, 13 November 2014, https://www.npr.org/2014/11/13/363572151/after-solyndra-loss-u-s-energy-loan-program-turning-a-profit.

25 See https://budget.digital.mass.gov/bb/h1/fy10h1/prnt10/exec10/pbudbrief23.htm.

These views are changing in the US, where the Biden administration's Inflation Reduction Act (IRA) has created the funding and institutions to invest in supply chains for manufacturing energy technologies, shape demand and structure markets. The Biden administration has also proposed creating a sovereign wealth fund that would allow the US to invest in supply chains, technology and energy industries[26]. Relatedly, President Biden's competition enforcers have adopted a wholly different philosophy towards competition policy – that it exists to structure markets in ways that promote competition, rather than to make markets work better for consumers[27].

Similarly, European institutions are geared towards creating relatively neutral rules that construct a single internal market, that adopts a level playing field and a common external trade policy. The EU has extensive powers to harmonise internal market regulations to remove regulatory barriers that might disrupt the internal market, and it strictly regulates the manner in which states can support their industries, to avoid state subsidies that distort the internal market's level playing field (Article 107 Treaty on the Functioning of the EU). EU policymaking institutions are not designed to make coordinated investments in scaling supply and demand, or otherwise build competitiveness in industrial sectors (a problem criticised by Draghi, 2024).

European institutions have accordingly often seen industrial and competition policy as being in tension: proponents of industrial policy suggest that European competition policy keeps companies small, unable to invest at scale, and prevents the formation of large, internationally competitive conglomerates[28], while proponents

26 Josh Wingrove, 'Biden Aides Working on Proposal for US Sovereign Wealth Fund', *Bloomberg*, 6 September 2024, https://www.bloomberg.com/news/articles/2024-09-06/biden-aides-working-on-proposal-for-us-sovereign-wealth-fund.

27 See for example Khan (2018).

28 Jack Ewing, 'E.U. Blocks Siemens-Alstom Plan to Create European Train Giant', *The New York Times*, 6 February 2019, https://www.nytimes.com/2019/02/06/business/eu-siemens-alstom-train.html.

of European competition policy associate industrial policy with misadventures to create national champions (Caffarra and Lane, 2024). The European Commission's Directorate General for Competition is tasked with enforcing Europe's state aid rules, in an institutional nod to the scepticism competition enforcers have towards industrial policy (Caffarra and Lane, 2024). This tension is clear from the competitiveness report prepared by former Italian prime minister Mario Draghi for the 2024-2029 European Commission, which advocated judicious relaxing of competition rules where they prevent European companies from scaling up (for example in telecoms)[29], a suggestion that competition experts have sharply criticised (Duso *et al*, 2024).

China's success in solar manufacturing offers a few lessons for how to think differently about industrial policy. First, organic market competition alone should not determine a country's competitiveness in important industries. Industrial policy has a role to play in building competitiveness through driving domestic companies further than profit-maximising owners would, and using state tools to shape supply, demand and market conditions. These state actions can and should respond to the many market failures that arise within industrial sectors.

Second, competition is an essential tool of industrial policy. Industrial policy should structure markets in ways that commoditise products, solve coordination problems and generate competition along a value chain. Encouraging divestments and mergers, promoting interoperability and regulating firms' market power to maximise competitive pressure in a market are core tools of industrial, and not just competition, policy. Doing so leverages market forces to build more competitive and efficient companies. It is misleading and counterproductive to think of competition policy as a separate

29 Javier Espinoza, Henry Foy and Paola Tamma, 'Mario Draghi Confronts the EU's Merger Police', *Financial Times*, 9 September 2024, https://www.ft.com/content/515d5a42-a760-42f1-9afa-89d4dcdc2a99.

domain of economic policymaking, or of competition and industrial policy as being in tension[30]. The state has a role in structuring markets to optimise competitive pressure in ways that boost the international competitiveness of domestic companies.

Third, industrial policy for competitiveness should balance interregional competition and initiative alongside more centralised direction-setting. Modern industrial value chains are too complex for centrally-planned efforts to be successful: China's industrial policy in solar was to some extent adaptive and self-organising, with different provinces and municipalities competing to develop different parts of the solar value chain. Demand subsidies in California and by municipal electric utilities in Germany were also examples of regional initiatives that helped support the growth of the solar market.

US states generally have latitude to support local growth of competitive industries. States have been free to supplement IRA subsidies with their own policies, which enables some degree of interregional competition. Massachusetts's investments in its biotech industry since 2008 has shown how this sort of state initiative can be successful in the US, and Massachusetts Governor Healey in early 2024 announced a similar investment to support the state's cleantech industry[31].

This suggests Europe should reconsider its state aid rules. Europe's primary competition today is global, not within the EU. Internationally successful industries in some regions of Europe will generate spillovers for other regions of Europe (German carmakers have, for example,

30 It is telling that China's competition regulator (MOFCOM) also has broad responsibilities to manage trade relations, imports and exports, and foreign direct investment, suggesting a level of coordination across these policy domains. The US Federal Trade Commission, by contrast, has a narrower mandate around competition and consumer protection.

31 Jon Chesto, 'Healey Set to Take Big Swing to Build the Clean Tech Economy in Massachusetts,' *The Boston Globe*, 10 January 2024, https://www.bostonglobe.com/2024/01/10/business/healey-clean-tech-climate-investment/.

built supply chains in eastern Europe)[32]. State aid rules that prevent entrepreneurial and high-capacity European states from acting to boost their regions' global competitiveness may be misguided. Where possible, care should be taken to prevent richer regions from dominating poorer ones in purely intra-EU trade, but state aid rules should not prevent nimble states from acting. An equilibrium that is more equal but generates less investment does not serve Europe right now.

Fourth, companies become big by being competitive; they should not be made big so they can become competitive. Policymakers have an impulse to create national champions by fiat, such as with permissive merger policy or 'grand projects', in the hope that their champions will increase investment or become internationally competitive. This impulse often sees industrial and competition policy as being in tension. But industrial policy should instead aim to make companies good rather than big, by combining the right support with engineered competitive market conditions.

Fifth, market failures in scaling solar manufacturing are many and deeply interacting. The view in economics that policy instruments should target and correct specific market failures one-by-one is impossible or impractical in many real-life industrial policy scenarios. Policy intervention is justifiable where it improves on the overall equilibrium, and even if the instrument of intervention targets several different market failures at once.

32 Piotr Liss, 'Automotive Industry in Central and Eastern Europe', *RSM*, 23 June 2021, https://www.rsm.global/poland/en/insights/doing-business-poland/automotive-industry-central-and-eastern-europe.

4.6 Case study: wind manufacturing

The wind industry looks like it will be next on the list of once-great US and European industries fallen to competition from China. High interest rates and supply-chain bottlenecks have slowed wind deployment in the US and Europe and created problems for western manufacturers, with GE-Vernova[33], Siemens-Gamesa[34] and Vestas[35] all facing financial trouble. A 3.2 percent rise in interest rates increases the cost of a wind farm by 25 percent and industry representatives say offshore wind projects became 40 percent more expensive in the EU between 2021 and 2023 (Draghi, 2024). Grid interconnection bottlenecks, planning delays and NIMBYism have also kneecapped growth in wind deployment in developed countries: wind farms take on average six years to permit in Europe, with the shortest permitting times at two years and eight months (in Latvia) and the longest at nine years (in Ireland) (Draghi, 2024).

China has largely avoided these pitfalls owing to government support building out supply chains and supporting deployment. China has been deploying substantially more wind domestically, installing 56.6 GW in 2022 (GWEC and BCG, 2023) (compared with 19 GW in Europe and 7 GW in the US)[36]. China's wind deployment is also growing more strongly than in other regions, with 75.9 GW deployed in 2023 (GWEC, 2024), compared with flat deployments in Europe (18.3

33 Stanley Reed, 'GE Vernova May Cut 900 Offshore Wind Jobs as It Scales Back,' *The New York Times*, 20 September 2024, https://www.nytimes.com/2024/09/20/business/ge-vernova-offshore-wind-layoffs.html.

34 Jennifer Collins, 'Discontent at Siemens Energy over Wind Division Losses – Media Report,' *Clean Energy Wire*, 28 February 2024, https://www.cleanenergywire.org/news/discontent-siemens-energy-over-wind-division-losses-media-report.

35 Craig Richard, 'Vestas' losses widen despite 'positive trajectory' of wind turbine sales,' Windpower Monthly, 14 August 2024, https://www.windpowermonthly.com/article/1885006.

36 See *Our World in Data*, 'Installed Wind Energy Capacity,' last updated 12 December 2023, https://ourworldindata.org/grapher/cumulative-installed-wind-energy-capacity-gigawatts.

GW) (Wind Europe, 2024) and the US (6.4 GW) in 2023 (WWEA, 2024). China has combined this rapid increase in demand with trade protections for its domestic manufacturers and intense domestic competition to build competitiveness in its wind industry.

Overall, China now dominates wind manufacturing (with 82 GW annual capacity) and has more advanced technology. Europe is a distant second (with 21.6 GW capacity) and the US and India rank in third and fourth places at 13.6 GW and 11.5 GW capacity respectively. China also has a dominant market share in production of many components, with 82 percent of converter and casting production, 80 percent of gearbox production and 73 percent of wind power generator production (GWEC and BCG, 2023). China plans to add 17 onshore nacelle assembly plants and 47 offshore nacelle assembly plants, with the rest of the world planning to add two onshore and eight offshore nacelle assembly plants (GWEC and BCG, 2023). China is the only region with a fully integrated supply chain with enough capacity for anticipated growth. Chinese wind manufacturers are also now one generation ahead of western manufacturers in technology (with larger turbine sizes which indicate greater efficiency in wind power generation) (GWEC, 2024). China's government has prevented consolidation of wind manufacturers, supporting an intensely competitive market structure (GWEC and BCG, 2023).

Chinese wind manufacturers have historically largely supplied China's domestic market, but they are now outcompeting western manufacturers in projects globally, winning projects in Germany[37] and

37 Riham Alkousaa and Nina Chestney, 'Chinese Wind Turbine-Makers Move into Europe as Trade Tensions Flare,' *Reuters*, 19 July 2024, https://www.reuters.com/sustainability/climate-energy/chinese-wind-turbine-makers-move-into-europe-trade-tensions-flare-2024-07-19/; Craig Richard, 'Chinese Manufacturer Sany Targets European Markets with 8MW Onshore Wind Turbine,' *Windpower Monthly*, 24 September 2024, https://www.windpowermonthly.com/article/1889659.

generating a wave of outbound investment into developing countries[38].

US and European wind manufacturers have called for support through permitting consolidation, cutting manufacturing capacity and slowing innovation through agreements to curb turbine growth and prevent obsolescence of their current models. They claim this will enable them to return to profitability and make larger investments (GWEC and BCG, 2023).

Industrial policy for competitiveness in wind energy demands a different response: expanding markets by increasing demand, making it easier and cheaper to deploy wind power through faster permitting, interconnection and low-interest financing, investing across the supply chain to reduce unit costs, preventing consolidation of manufacturers to maintain high levels of competition and supporting manufacturers to innovate faster by incentivising larger turbine sizes.

Increasing demand for wind power without China's large and growing electricity market presents a challenge. Reducing costs for deploying projects domestically with faster permitting and interconnection, lower financing costs and scaling supply chains will help drive demand. Electricity load growth from artificial intelligence data centres[39], electric vehicles and industrial decarbonisation can also help drive demand in the US and Europe, as can partnering with developing countries that are building out their generation capacity. Unlocking each of these sources of demand is rife with coordination failures that wind turbine manufacturers cannot be expected to solve on their own.

38 William Sandlund and Edward White, 'China Outbound Investment Surges to Record Levels on Clean Energy "Tsunami"', *Financial Times*, 1 October 2024, https://www.ft.com/content/67887a67-f188-459a-b927-147b454fe335.

39 Brian Deese and Lisa Hansmann, 'America Needs an Energy Policy for AI', *Heatmap*, 12 September 2024, https://heatmap.news/technology/ai-additionality-framework.

4.7 Conclusion

China's success in solar manufacturing demonstrates how effective a certain form of industrial policy can be in building competitiveness in an existing industry. But in the West, these institutions have been left underdeveloped, partly from a sense that organic market competition rather than state policymakers should determine competitiveness. Capturing economic opportunity in the energy transition involves thinking differently about industrial policy. It involves developing the tools and institutions to shape demand, supply and market conditions in ways that help domestic industries build international competitiveness, seeing industrial and competition policy tools as intrinsically related and mutually supportive, leveraging interregional competition and renouncing the impulse to create large national champions using policy.

The stakes are high: the US, Europe and many other regions have made growth in green industries central to their economic strategies, while China is hoping to replicate its success in solar in a range of other critical industries, including EVs, batteries, wind and electrolysers. The economic winners in the energy transition will be the states and regions that develop appropriate institutions to succeed at building competitiveness in emerging clean-energy industries.

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5 From periphery to core: the climate and energy journey of European foreign policy

Margherita Bianchi and Nathalie Tocci

5.1 Introduction

Climate and energy policy are on a journey. For years they were relegated to the margins of European foreign policy. While the European Union prided itself on being a climate leader in world affairs long before its European Green Deal, climate featured only sporadically in foreign and security policy until the 2015 Paris Agreement. Although energy diplomacy underwent bouts of activity, it was also compartmentalised and separated from the core of foreign policy.

This slowly began to change over the last decade, with a strengthened emphasis on climate and energy in the past five years. Spearheaded by the European Green Deal, the EU doubled down on decarbonisation and equipped itself internally to confront the monumental challenge of climate change. The European Green Deal, beyond representing a concrete plan to reach net-zero greenhouse gas emissions in three decades, also entails an all-of-government ecological approach.

Institutionally, the EU adapted to this by upgrading climate in the European Commission, and by including climate and energy matters in various configurations of the Council of the European Union, and on the agenda of the European Council. The same is true of the European Parliament, with dedicated committees focusing on environment and energy respectively, complemented by climate permeating other key areas including budget, economic and monetary affairs, employment and social affairs, transport, agriculture and development.

In Europe, climate issues played out against a backdrop of crises – economic, environmental, health and political – building a sense of strategic prioritisation. The resilience of the European Green Deal during the COVID-19 pandemic and the subsequent energy crisis is emblematic in this sense. External shocks such as the Russian invasion of Ukraine have also changed the way the EU looks at energy security and affordability, reinforcing Europe's green agenda.

As far as foreign policy is concerned, however, the EU is still far from where it should be. While climate is increasingly framed as part of a series of nexuses – connected with migration, security, conflict, defence – the EU has not yet extended this all-of-government approach to its external action and is far from communicating climate coherently outside its borders.

At least on paper, the European Green Deal recognises this external dimension: the 2019 Commission communication on the deal states that *"climate policy implications should become an integral part of the EU's thinking and action on external issues"* (European Commission, 2019), conveying the message that efforts to fight global warming should be a guiding principle for EU foreign policy.

This external dimension is reflected in the strategy (Giuli and Bianchi, 2023). First, the European Green Deal features the goal of a 'just transition' both within and beyond EU borders. Second, through the deal, the EU seeks to take a leading role in setting international regulatory standards for the green transition. Third, the EU aims to support the multilateral climate agenda – the continuation of which also plays an enabling and legitimising role for domestic climate policies. Fourth, the green deal points to an industrial transformation that ensures technological leadership in decarbonised and clean energy supply chains, in line with the ambition to build European strategic autonomy. In the political institutional cycle up to 2029, this is where the major focus should lie.

5.2 Origins: the EU as a climate leader at the margins of foreign policy

The EU began developing climate policy in the 1990s. Since then, it has built up a large portfolio of climate mitigation policies and governance tools, including targets and policies to reduce greenhouse gas emissions, increase the share of renewable energy and strengthen energy efficiency across sectors. Today, it has a dense regulatory framework.

In the 1990s and early 2000s, however, attention was focused on the internal dimension of decarbonisation: when the EU released its first security strategy in 2003, climate change and the energy transition were not mentioned (European Council, 2003). In fact, when energy was discussed in the context of foreign and security policy in the early 2000s, it was mainly in terms of the need to access cheap and reliable hydrocarbons to ensure Europe's energy security. As a major consumer – but not producer – of oil and gas, the European energy-foreign policy nexus revolved around ensuring greater access to fossil fuels. This approach reflected the broader policy debate in those years, in which the geopolitics of energy was basically understood as the geopolitics of fossil fuels, not of climate change or the energy transition.

The awareness of climate change then was not what it is today, but it is nevertheless striking in retrospect that this was the case even though international climate diplomacy had been ongoing for several years. The EU had emerged as a key player in this context, especially after the US withdrew from the Kyoto Protocol in 1999, handing over the mantle of climate leadership to the Europeans. Climate diplomacy played out in its separate bubble, and climate change and the energy transition were absent both conceptually and practically from European foreign and security policy.

In the first decade of the twenty-first century, the first timid steps to integrate climate change into European foreign policy were taken (Oberthür and Dupont, 2021). In 2006, the EU Sustainable Development Strategy presented a comprehensive framework for sustainable development. The European Commission was also one of the first bodies worldwide to identify climate change as a global security threat. From the late 2000s, the EU intensified its economic support for developing countries' energy transitions and climate adaptation strategies. What today falls under the broad umbrella of climate finance has become one of the fastest growing dimensions of EU external policy: back in 2009, the EU committed €7.2 billion to its first formal package of climate funding (Lazard and Youngs, 2021).

The EU moved to speak with one voice, with the rotating EU presidency representing the union in international climate negotiations and the Commission providing the necessary support to substantiate the EU's climate goals. The failed Copenhagen Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009 spurred the EU to take further action. Beyond engaging in the UNFCCC, Europeans began engaging with third countries, regional organisations and transnational climate initiatives more systematically. They understood that their climate ambitions would be successful only if embedded in broader climate coalitions.

5.3 Enlightenment: climate and energy move towards the core

The entry into force of the Treaty of Lisbon in 2009, the 2015 Paris Agreement, and especially the 2019 European Green Deal, contributed to increased prioritisation and mainstreaming of climate and energy in European foreign and security policy.

The Lisbon Treaty saw the establishment of hybrid roles and institutions including the triple hatted High Representative, Vice-President of the Commission and Chair of the Foreign Affairs Council, and the European External Action Service (EEAS). This created a more conducive context for climate and energy to be gradually mainstreamed into EU foreign policy. Unlike the 2003 European Security Strategy, the

2016 EU Global Strategy mentioned climate 21 times and energy 36 times (EEAS, 2016).

Today there is far more coordination and coherence both horizontally between institutions in Brussels and vertically with member states on climate and energy matters. Since 2011, the Foreign Affairs Council has repeatedly stressed the importance of climate diplomacy (Jackson *et al,* 2024). This framing has spurred a series of initiatives. By 2011 the EU had launched a climate diplomacy programme to begin engaging on the foreign policy dimensions of climate change and EU institutions began running awareness-raising sessions on climate security for their diplomats (Zwolski and Kaunert, 2011).

The Paris Agreement and the European Green Deal elevated climate, energy and environmental matters in EU foreign policymaking. Until 2018, the EEAS did not deal with climate and energy at all, whereas today it includes a climate, environment and energy division premised on the awareness that climate change and environmental degradation represent an existential threat to Europe and the world. Within the EEAS, climate policy also gained prominence with the appointment of an ambassador-at-large for climate diplomacy.

Climate foreign policy has entered the strategic agendas of the Commission's directorates-general for climate action and international partnerships, and has become relevant in its directorates-general for internal market, industry, entrepreneurship and SMEs, trade and taxation and customs union (Jackson *et al*, 2024). The directorate-general for energy also focuses on external energy policy and energy diplomacy around the clean energy transition. In recent years, the Foreign Affairs Council has periodically turned its attention to climate and energy matters, especially when they have become matters of urgency, for instance in the lead up to the annual Conference of Parties (COP) or at times of energy crisis, such as that ignited by Russia's invasion of Ukraine in 2022. In the last decade climate has been heavily securitised in European public discourse and elevated to an *"existential threat"* by both the Commission and the Council. The language of climate urgency has been borrowed from the scientific reports of the Intergovernmental Panel on Climate Change and has become a dominant framework in several international institutions.

In policy terms, the last five years have also seen 'nexus' thinking permeating European foreign and security policy. Back in 2008, High Representative Javier Solana put the spotlight on the climate-security nexus for the first time in a policy paper to the European Council (European Council, 2008). It took several years for foreign ministries to respond. Today, however, the idea that climate change represents a security threat multiplier is well understood across European diplomacy: in March 2024, the Council reiterated[40] the gravity of the accelerating 'triple planetary crisis'[41] of climate change, biodiversity loss and pollution, which aggravates security concerns.

Yet the EU struggles to translate the impressive number of policy documents it has generated on climate security into tangible action and results in specific strategic contexts (Lazard and Youngs, 2021). The defence policy community woke up a decade later. In 2019 European defence ministers discussed for the first time the climate-defence nexus. They have since started working on how to restructure their work to better anticipate crises caused or exacerbated by climate change, retailor their operations and adapt their capabilities to warmer climates and extreme weather events[42].

40 See Council of the EU press release of 18 March 2024, 'Green diplomacy, Council conclusions reaffirm the EU's commitment to work closely with partners to accelerate a global just and inclusive green transition', https://www.consilium.europa.eu/en/press/press-releases/2024/03/18/green-diplomacy-council-conclusions-reaffirm-the-eu-s-commitment-to-work-closely-with-partners-to-accelerate-a-global-just-and-inclusive-green-transition/.

41 See United Nation Framework Convention on Climate Change blog post of 13 April 2022, 'What is the triple planetary crisis?' https://unfccc.int/news/what-is-the-triple-planetary-crisis.

42 For example, the performance of helicopters in Afghanistan was compromised by dust and the heat, contributing to the launch of an EU permanent structured cooperation project on 'Helicopter Hot and High Training'.

Recent years have also seen the climate and energy nexus becoming embedded in other areas of external action, including trade and development[43]. The Multiannual Financial Framework (MFF) running to 2027 foresees that 30 percent of the Neighbourhood, Development and International Cooperation Instrument (NDICI) funding is allocated to climate and the energy transition, amounting to around €25 billion over seven years. Geographically, most NDICI funding is channelled to Africa, which is expected to receive around half of the total funds available[44]. Furthermore, part of NDICI is dedicated to a €53.5 billion European Fund for Sustainable Development, aimed at triggering private sustainable investments, seeking to replicate the success of previous initiatives such as the Commission's 2016 external investment plan. The EU estimates that over half a trillion euros worth of private investments could be mobilised in this way.

Regarding trade, at the softer end of the trade policy spectrum, the EU has moved towards substantiating the sustainable development chapters in its trade agreements and including alignment with the Paris Agreement as an essential element of future free trade deals. On the harder end of the spectrum, it has established a carbon border adjustment mechanism (CBAM), set to enter into force in 2026. CBAM is driven primarily by an internal rationale: preventing European companies from relocating their emission intensive activities outside the EU and mitigating the competitive disadvantage for European industries that are subject to carbon pricing.

43 Julia Grübler, Roman Stöllinger and Gabriele Tondl, 'Are EU Trade Agreements in Line with the European Green Deal?' *Vienna Institute for International Economic Studies*, 15 February 2021, https://wiiw.ac.at/are-eu-trade-agreements-in-line-with-the-european-green-deal-n-484.html.

44 Around half of the EU's development assistance under its geographic programmes is channelled to Africa, to which one should add the assistance Africa receives under the thematic and rapid response programmes. See https://international-partnerships.ec.europa.eu/funding-and-technical-assistance/funding-instruments/global-europe-neighbourhood-development-and-international-cooperation-instrument_en.

However, there is also an ambition to trigger virtuous climate policies beyond the EU (Vanheukelen, 2011). Whether these take the form of 'cap and trade' market-based mechanisms, carbon taxes, regulations or funding instruments does not matter, so long as such policies are effective in inducing decarbonisation. The stick of CBAM should in theory provide an incentive in this respect. The EU has discussed or introduced other major rules impacting global supply chains – notably the EU Corporate Sustainability Due Diligence Directive (Directive (EU) 2024/1760) and the Regulation on Deforestation-free Products (Regulation (EU) 2023/1115) – with comparatively little attention.

The last five years have also seen a growing nexus between climate, energy and industrial policies. This has been an integral element of the debate on European strategic autonomy, originally confined to the defence space, and then expanded to cover the economy, energy and technology too. Given that the EU is a consumer rather than a producer of fossil fuels, decarbonisation and the development of European green capacity offer the opportunity enhance strategic autonomy. Reduced fossil fuel dependence on Russia would enormously strengthen European autonomy and resilience. However, the EU has become increasingly cognisant of the new interdependences embedded in green supply chains, from critical minerals to green technologies, and how these could also be weaponised, especially by China, which has an edge in these sectors.

Driven by the need to secure supplies and mobilise green growth, the EU has started establishing institutional, regulatory and funding mechanisms to foster European green industries and technologies and has established industrial alliances in areas like raw materials, batteries, clean hydrogen and circular plastics (Raimondi *et al*, 2023). Seeking to develop such capacities only within the EU, however, is either impossible, as in the case of raw materials, or prohibitively costly, as with almost everything else. This is where the EU's €300 billion Global Gateway initiative is playing a role in developing resilient green supply chains, especially with partners in the Global South, becoming the export arm of a new EU industrial policy while helping economic development in the EU's partner countries (Tagliapietra, 2024).

As climate issues clearly become increasingly pertinent across various foreign policy arenas, the EU faces difficulties in finding and projecting a cohesive and coherent response. Climate diplomacy is spread across functions and institutions without sufficient incentives to coordinate effectively. Similarly, an unclear division of responsibilities has so far made climate-related actions a low priority in external relations (Jackson *et al,* 2024). This is partly because although some aspects of foreign policy are shared between the EU and its member states, it largely remains the responsibility of EU countries. This often leads to fragmented and inconsistent positions at EU level.

Furthermore, the EU's approach to climate mainstreaming in foreign policy lacks a long-term vision, relying instead on annually developed near-term strategies in the form of European Council conclusions (eg on climate diplomacy) or COP negotiating positions. The lack of a longer-term vision is crystal clear when looking at the fragmented EU decarbonisation vision/action toward the larger Mediterranean area, which still appears embryonic[45] even though it is key to advancing regional just transition efforts (Tocci *et al,* 2024).

5.4 Staying the course: consolidating and expanding the green deal in European foreign policy

The journey towards ever-greater integration and mainstreaming of climate and the energy transition in European foreign policy risks stalling, with a growing 'greenlash' in Europe[46]. On the one hand, this

45 See statement by EU Med countries of Croatia, Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia and Spain at the first MED 9 Energy Ministerial summit on 18 May 2023, https://www.gov.mt/en/Government/DOI/Press%20Releases/PublishingImages/Pages/2023/05/18/pr230740en/PR230740e.pdf.

46 Nathalie Tocci 'After two years of real progress on climate, a European 'greenlash' is brewing,' *The Guardian*, 12 July 2023, https://www.theguardian.com/commentisfree/2023/jul/12/progress-climate-european-greenlash-populist-right.

can be read as evidence of the fact that the transition is happening: it is one thing to support climate action when it is only theoretical, and another to continue supporting it when it becomes real. The transition risks creating not just winners but also potential losers, making it inevitable that the latter will make their voices heard. Their concerns must be addressed and eventually compensated otherwise the transition risks being derailed.

This also applies to neighbouring countries, where dissent around climate policies could grow if the EU manages the transition poorly. On another level, populist and far-right parties have latched onto climate policy, particularly that pursued by 'Brussels', demonising it. EU climate policies, in their narrative, fuel inequalities and injustice, in the same way that austerity and the lack of migration control were lambasted in the past, enabling their first surge (Tocci, 2022).

The 2024 European election initially seemed to confirm the 'greenlash', with far-right parties rising across major European countries, centre-right parties becoming more sceptical towards climate action and the Green group shrinking from 74 to 53 seats in the European Parliament. Yet this made the group more interested and amenable to compromise than they were last time, when they voted against Ursula von der Leyen as president of the European Commission. Provided the president assured that there would be no backtracking on the European Green Deal, they signalled their readiness to support her for a second term. This meant both that the Greens entered the *de-facto* governing majority and that von der Leyen did not need to bend over backwards to lure the far-right and climate-sceptic European Conservatives and Reformists to secure her re-election. Ultimately, she presented a fairly ambitious agenda that held the line on the European Green Deal.

The European Green Deal has held, although it is now couched in the broader narrative of prosperity and competitiveness aimed at achieving green growth. When it comes to climate mainstreaming in foreign policy, what could, and should this actually mean? Institutionally, more could be done to break down silos and put climate and the energy transition at the core of foreign policymaking. First, maintaining a separation between the directorates dealing with climate and energy is artificial at best, counterproductive at worst. Given that three quarters of climate action is related to the energy transition, it is hard to understand how concrete progress can be made without greater institutional synergy, if not a merger, between the two.

Institutional separation between energy and climate leads to very different, and at times contrasting, and often uncommunicative, institutional cultures, networks and policy approaches. For instance, when the climate and the energy policy communities work on the external dimensions of their respective policy fields, the former concentrates almost exclusively on multilateral climate negotiations in the context of the UNFCCC, whereas the latter works on energy security and the functioning of international energy markets. Both are important and intertwined, yet in practice they proceed along parallel lines. The strategic cost of such separation was made abundantly clear following the outbreak of war in Ukraine, when institutions scrambled to reconcile the narrative, policy and practice of energy security with the transition. A failure to break down silos, or even worse, further fragmentation, would seriously jeopardise EU's climate ambitions.

Within the EU foreign policy machinery, there are still only a handful of officials working on climate and the energy transition in the EEAS. For a service that should represent the global face of the EU's new green *raison d'être*, this hardly communicates a sense of priority. Similarly, while the Foreign Affairs Council occasionally addresses energy and climate matters, it still does so too sporadically. The regional and global implications of climate change and the energy transition ought to become regular topics of in-depth discussion, followed by action by European foreign ministers.

Finally, the European foreign policy community needs to work in greater sync with civil society, the media and the private sector on climate and the transition. Given that the transition will fundamentally change how we buy, work and live, civil society and the media are crucial in informing and engaging the public so that it is prepared for what promises to be a tumultuous journey.

In policy terms, doubling down on climate finance and green global value chains will be essential. CBAM is being critiqued from a development perspective, given the concern that it will adversely affect the development prospects of the Global South. Especially for less advanced economies, adaptation appears particularly difficult due to expanding populations, lack of financial and administrative resources for regulatory changes, and the long timeframes generally required for industrial transformation. In particular, the worry is that developing countries with high shares of carbon-intensive exports to the EU would be exposed to additional costs, and therefore worse terms of trade and reduced export shares.

Given the limits hindering the transformation of developing countries' industries, it should be the EU's responsibility to support the development of such capacities, by putting in place the financial and technical support for such countries. The assumption of a future extension of the CBAM to other sectors of EU imports seems particularly punishing for emerging economies such as Russia, South Africa, India and China, for countries in the European neighbourhood such as Algeria, Turkey and Ukraine as well as for sub-Saharan Africa and Southeast Asia.

This tension takes place in a time of particularly complex relations between the EU and the Global South. The Global South has been severely impacted by the EU's approach to the energy crisis, which has resulted in the EU redirecting significant quantities of liquified natural gas to Europe for its own security. At the same time, the EU is seeking to reconnect with various actors in the Global South, both to regain influence in the context of the growing presence of strategic rivals (China and Russia in particular), and to diversify gas supplies and access to raw materials for its transition. It is mobilising trade instruments which are not always perceived as favourable by developing countries interested in developing green supply chains locally (Giuli and Bianchi, 2023). This connects to the broader goal of significantly expanding climate finance.

Nonetheless, whilst the Global North in general continues to fall short of providing the funds it must deliver to ensure the transition of the Global South as well, the EU is the best of a bad lot. This is true both in terms of absolute levels of climate finance, where Europeans contribute around half of global climate funds, and in terms of the type of finance provided, with over half of all climate funds spent on climate adaptation (rather than on the more popular climate mitigation) (European Commission, 2021).

Particularly at EU level though, the challenge is that of implementation. As mentioned earlier, 30 percent of the EU's Neighbourhood, Development and International Cooperation Instrument (NDICI) is expected to be channelled to climate and the energy transition. However, given that specific programmes are developed together with third countries, which often have different priorities, there is little guarantee that these funds will actually be spent on climate.

The EU is right to designate a significant percentage of its unified external funding instrument to climate mitigation and adaptation. However, much like it has established specific internal initiatives such as the Just Transition Fund and the Climate Social Fund to prevent the potentially regressive socio-economic effects of the transition and thus ensure its political acceptance, it will need to develop parallel external measures to make the transition geopolitically sustainable and avoid deepening the climate cleavage between the Global North and South. This is not least because of the important global recognition that countries have *"common but differentiated responsibilities and respective capabilities' to take climate action"* – a staple of the international climate consensus since the Kyoto Protocol.

There is a risk that shifting priorities at the EU level could be reflected in a smaller or slower disbursement of EU financial reallocations, despite the overall support of the new Commission and parliament for the European Green Deal. On paper, the EU and its member states are the world's largest public climate finance providers, contributing €28.6 billion in 2023 alone[47]. But amidst growing geopolitical tensions and security concerns, the external climate and development budget is increasingly under pressure, something that the world's poorest countries cannot afford. The lack of climate finance has undermined trust between developed and developing countries at UN climate negotiations: in the case of Europe, it has put a significant strain on its relations with Africa (Karkare and Medinilla, 2023; Knaepen and Dekeyser, 2023).

Finally, the years ahead will be marked by the arduous task of charting an equilibrium between energy security, affordability and sustainability in the context of decarbonisation, revolving around China and the US. Following China's refusal to export rare earths to Japan following a diplomatic dispute in 2010, Western governments have begun considering strategic vulnerabilities related not only to their dependence on Chinese rare earth elements but also to other critical raw materials.

Security issues related to critical raw materials are not only linked to mining activities but also to refining and processing activities, on which no country can decouple entirely in the short term from Beijing. Supply chain bottlenecks create risks around volume availability (eg shortages), price volatility and (geo)political risks (eg dependency). Vulnerabilities in key supply chains are created not only by availability of resources but also by normative issues, such as supplier transparency, human rights, social rights and environmental standards, which must be addressed by the EU (Raimondi *et al,* 2023).

Recent years have been marked by growing protectionism in renewable technologies and electric vehicles in response to China and by transatlantic tensions revolving around the US Inflation Reduction Act. The EU and US, along with other G7 countries, have also announced infrastructural programmes to address Beijing's foreign reach and

47 See Council of the EU, 'Financing the Climate Transition', 6 November 2024, https://www.consilium.europa.eu/en/policies/climate-finance/.

its Belt and Road Initiative. The EU established the Global Gateway and the G7 launched the Partnership for Global Infrastructure and Investment. All of this has yielded a more competitive approach to climate and especially towards China.

On the one hand, this reflects the growing appreciation of the security risks of excessive dependence on China both in Europe and the US. On the other hand, swinging the pendulum too far towards disengagement from China risks hampering the transition and leading to prohibitively high costs. Finding an equilibrium between engagement and disengagement with China, boosting European production with public funds and a capital markets union and diversifying green value chains through strengthened partnerships in the Global South will be essential.

Complicating the search for a balance between decarbonisation, trade, industry and development cooperation goals is the growing distrust in the ability of multilateral institutions to dampen the trade tensions associated with the energy transition. These very institutions could in principle provide useful platforms to ensure that climate policies do not devolve into protectionism. However, there seems to be little interest in their revitalisation and adaptation to new climate demands.

5.5 Looking ahead

The 2024-2029 cycle is testing the EU's ability to better mainstream climate into its foreign engagement and action. Its ability to address the above-mentioned weaknesses will be a defining feature of Europe's role in the global energy transition. As well as this, the very ambitious Fit for 55 targets should be achieved by the end of this decade and many external tools are still to be defined, completed or operationalised in these five years.

A *sine qua non* for the success of the European Green Deal is that the EU equips institutions, governance and communication for the challenge. Institutionally, stronger coordination is needed to better assess the speed of the transition and the evolution of energy security across regions and sectors and ultimately to be better aligned across areas of government. It would also be key for the EU to promote stronger integration of global energy and climate needs into a more comprehensive global governance architecture as much as it can. The current fragmented architecture does not account for the complexities of the transition, and is based on old *modus operandi* that will progressively change, including outdated producing-consuming frameworks (Franza *et al,* 2020).

Another lesson from the 2019-2024 cycle is that external perceptions do matter and must be anticipated. The EU's campaign to lead by example should be carefully crafted as it could be perceived as moral grandstanding and inhibit consensus in other countries. More attention needs to be paid to how European initiatives are perceived around the world in relation to those of other advanced economies: developing countries that are more dependent on world trade appear less hostile to US industrial policy initiatives such as the Inflation Reduction Act than to European measures such as the CBAM, as the Inflation Reduction Act shows potential for reducing the cost of deploying clean technology around the world, including in developing countries or emerging economies (Giuli and Bianchi, 2023).

CBAM risks being perceived in the Global South as a tool which fails to balance penalising aspects with widespread benefits. Many in Brussels acknowledge that the EU was unprepared to engage with partners on the CBAM and its impacts – and this is not how Europe should act. Communication on the external dimension of the Green Deal has been a sticking point for the EU. To meet its stated ambition to be a global example, Europe must integrate climate-conscious policies into every aspect of its foreign policy and foster dialogue to engage others.

In this sense, the EU should foster coherence between strategic and development objectives. Developing economies have many partners to choose from. Europe must foster political dialogue and meaningful country ownership when setting up its external initiatives such as the

European Global Gateway (Bilal and Teevan, 2024). There must also be a much stronger linkage between the Global Gateway and EU's domestic competitiveness agenda, finding ways to set win-win nearshoring strategies with strategic regions across the world – especially Africa. This exercise needs to be supported by the key principle to create sustainable global supply chains and foster mutual progress in the sustainable energy sector. Another tool in the hands of the EU is external financial support – climate finance must grow in quantity and quality, and Europe should do anything in its power to make it happen.

The EU should also adapt to the changing concept of security and its new features in a highly decarbonised world. While traditional security concerns regarding fossil fuel supply are expected to remain relevant in these next five years, new forms of energy security are rapidly changing the global landscape: while renewables increase decentralisation and regionalisation, they also retain a global dimension (mostly related to critical mineral availability and the integration of global value chains). In this sense, a much more informed debate should take place over how to secure our climate targets on time and in a cost-effective manner. This should be pursued by avoiding conflict with superpowers (ie the US and China) while moving quickly in those key sectors or segments where Europe can be competitive internationally, with benefits both in terms of energy transition and socio-economic performance.

The EU needs to focus on strengthening its competitiveness through its own characteristics (competition and single market integration) (Raimondi *et al,* 2024) and avoid embracing excessive and ineffective protectionist policies. This would allow the EU to establish more cooperative external policies and limit retaliatory trade measures. On the other hand, the EU and its member states should jointly and carefully consider the overall strategic and socio-economic benefits of developing local supply chains. To do so, the EU needs to have a systemic approach, coordinated and supported by a strategic vision for supply chain integration.

The EU can also lead global decarbonisation through an important dimension of its power that has remained unaffected by previous crises – its ability to regulate global markets. If wisely used, this is a strong tool to scale up sustainable investment through taxonomies, standards and labels. The EU can and should continue promoting higher environmental, social and governance standards and non-price criteria which can also be relevant in incentivising the innovation required to achieve EU targets. In this context, European industry could leverage its strengths, such as its strong track record on high environmental and sustainability standards.

A solid transatlantic green partnership could definitely help, although EU-US relations have not been without tensions in the recent past (Marconi *et al,* 2024). If on the one side the energy crisis in the past three years contributed to a rapprochement between the two, President Trump's 'energy dominance' vision will likely imply a big step backwards: his agenda foresees a strong cut in energy prices in the US that might have repercussions in Europe – where gas prices are already three to five times higher and electricity prices are two to three times higher. Such a situation would impact the EU's industrial competitiveness and capacity. Trump's assertive energy dominance in international markets could also imply more sanctions (eg on Iran) or the use of the US liquified natural gas (LNG) as a bargaining chip to ensure new deals (in particular with Europeans). Cutting the environmental regulatory tape in the US is instrumental to this goal – for instance by allowing greater flexibility on methane emissions.

However, there is also common ground to build on, such as the EU's cooperation with the US in the recycling of critical raw materials as a way to 'decouple' (the US) or 'derisk' (the EU) from China's quasi-monopoly. This could contribute to lower dependence on mineral imports and reduce the environmental impact of clean energy technology. Moreover, although the fate of the US Inflation Reduction Act (IRA) and its anticipated $1.045 trillion worth of climate and energy provisions is at time of writing insecure, building broad

Congressional support to fully repeal it could prove challenging, since many Republican representatives have voters who gain from specific IRA benefits.

Also, the US is likely not willing to lose the battle around manufacturing and industrial capabilities *vis-à-vis* China. The direction of transatlantic technology and energy cooperation will be affected by both domestic (in both Europe and the US) and international factors that are difficult to entirely capture at the time of writing, but in the meantime the EU could work to build stronger ties with the US sub-federal level to make sure climate action/cooperation continues and gets stronger through other channels.

Changes in the energy security landscape also mean maintaining trade interdependence in a highly decarbonised world with current fossil fuel exporting countries in the neighbourhood. As complex as it is, the EU cannot continue to delay the orderly and coherent transformation of its relations with traditional energy partners (and the Mediterranean area in particular – where a smarter management of the region's competitive and comparative advantages could contribute to the climate pathway of the entire area). Finally, the 2024-2029 Commission should focus on scientific and technological cooperation, education and skilling efforts both as a factor to strengthen industrial capacity internally, but also to support advancements globally (specifically in partner countries).

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6 Climate action: A view from the Global South

Mauricio Cárdenas

6.1 Introduction

Between-country global inequality has fallen during the last few decades. This has been largely the result of faster economic growth in some of the world's most populous countries, notably China and India. The benefits of trade networks, access to capital and better technologies in regions with low physical and human capital have been apparent (Milanovic, 2016). However, at least since the earlier 2010s, this trend seems to have stopped or even reversed. Global inequality is on the rise again. Climate change may disrupt convergence in GDP *per capita* across nations even more.

While countries in the Global North have the financial and technological resources to adapt to climate challenges, countries in the Global South are more vulnerable. Regions facing droughts or rising sea levels are more likely to experience severe disruptions to agriculture, infrastructure and overall productivity. The damage caused by climate change exacerbates pre-existing vulnerabilities, slowing down economic growth in the Global South.

Moreover, policy responses to climate change can sometimes create unintended consequences that burden developing and emerging nations disproportionately. Several well-intended policies, including environmental regulation and carbon taxes, aimed at accelerating the energy transition can have negative side-effects in the Global South. As advanced economies push forward with stricter environmental regulations, carbon border adjustment mechanisms and industrial policies with a protectionist bias, the gap between rich and poor nations can widen. For example, new trade barriers could make it harder for countries in the Global South to export their goods, placing additional strain on their economies. As a result, climate change has the potential not only to slow down economic convergence but to reverse it, increasing inequality between nations.

This chapter explores how both the direct effects of climate change and the global policy responses to it could contribute to deepening the divide between the North and the South. Climate change may be a global phenomenon, but its impact – and the way we respond to it – can widen the inequality gap between nations, with the most vulnerable regions facing a greater burden.

6.2 Coping with climate change in the Global South

Current levels of atmospheric CO_2 concentrations are more than 50 percent higher than pre-industrial levels. The energy sector is the largest contributor, with emissions stemming from electricity and heat production, fugitive emissions from oil, gas and coal, and other energy-related activities. Agriculture, forestry and other land use form the second-largest contributor to global greenhouse gas emissions, accounting for around 22 percent of global emissions (Minx, 2022). Land-use emissions primarily result from deforestation and conversion of forests into agricultural land. Deforestation in tropical regions, particularly in the Amazon, Southeast Asia and parts of Africa, is a significant source of emissions.

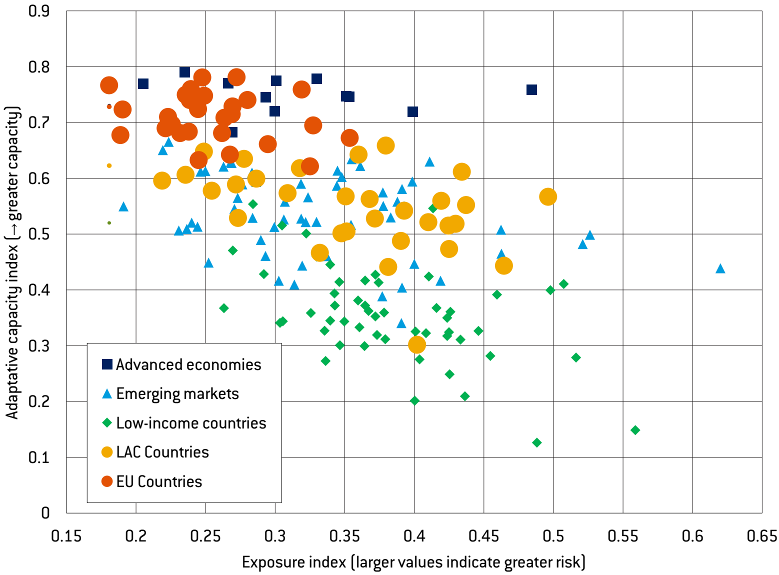
Countries in the Global South, particularly those near the equator, such as those in Central America, sub-Saharan Africa and Southeast Asia, are more exposed to extreme climate events including heatwaves, droughts, floods and hurricanes. The increased exposure in these regions poses significant risks to development, human health and economic stability. These regions are already prone to climate-related disasters because of their geographical location; climate change intensifies the frequency and severity of these events. Additionally, many countries in the Global South rely heavily on agriculture, a sector highly sensitive to climate fluctuations, and the degradation of land due to deforestation only amplifies these vulnerabilities (IPCC, 2014).

6.2.1 Exposure risk and adaptive capacity

The ability of countries to address climate change is shaped by a complex interplay of various risks: exposure, adaptation, transition and fiscal risks. These factors define how effectively a country can respond to the growing threats posed by climate change and are influenced by geographical vulnerabilities, institutional strength, financial capacity and the broader economic shifts required for a low-carbon future.

The greater risks of exposure to climate change faced by Global South countries become even more concerning when coupled with low adaptive capacity. The adaptive capacity of a country, which reflects its ability to cope with and adjust to climate challenges, is often limited in these regions. As illustrated in Figure 1, countries facing greater exposure to climate risks tend to have lower adaptive capacity, creating a situation of compounded vulnerability. Strengthening institutions and increasing access to financial and technical resources are essential steps for these nations to manage exposure risks and adapt effectively.

Figure 1: More-exposed countries have lower adaptive capacity



Source: Bellon and Massetti (2022).

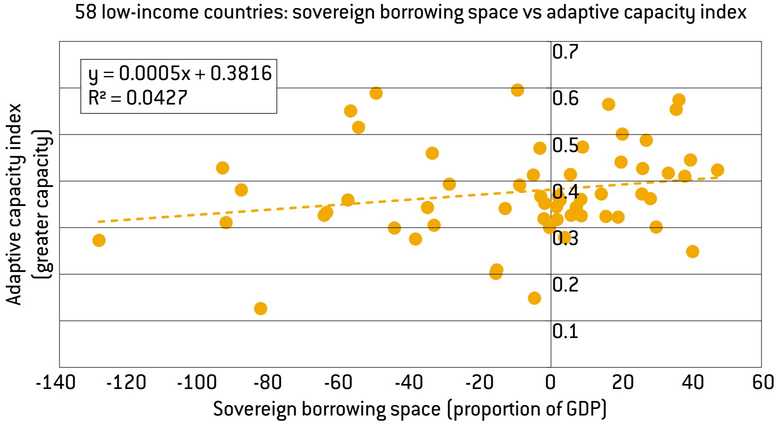
Countries with stronger institutions, better governance and greater financial resources – typically advanced economies – are more resilient and thus face lower adaptation risks. In contrast, countries in the Global South are significantly more vulnerable. Their adaptation risks are exacerbated by financial constraints, weaker governance structures and limited access to the necessary technologies and infrastructure to build resilience. This imbalance between developed and developing nations highlights a significant adaptation gap, which is further deepened by inadequate international support. According to the UNEP *Adaptation Gap Report* (2022), financial flows to developing countries for adaptation are severely underfunded, creating substantial obstacles for these countries in implementing the necessary projects and policies to protect against climate impacts. This funding shortfall must be addressed to bridge the adaptation gap and ensure that vulnerable nations are not left behind in global efforts to confront climate change.

6.2.2 Transition risks and fiscal capacity

Transition risks, which arise from the economic changes required to shift toward low-carbon economies, disproportionately affect carbon-intensive economies, especially in the Global South. Many of these countries, such as Venezuela and Nigeria, rely heavily on fossil-fuel exports and other carbon-intensive industries. As global demand for hydrocarbons decreases, these nations face significant fiscal challenges, which will further undermine their capacity to invest in climate adaptation. The decline in oil revenues can create a vicious cycle, limiting fiscal space and deepening vulnerability as resources for necessary adaptation measures become scarcer. Without adequate planning and international support, the economic transition could severely hinder the ability of these countries to build resilience.

Fiscal capacity is another critical factor in a country's ability to address climate risks. Advanced economies, with lower borrowing costs and greater budgetary flexibility, can finance adaptation and mitigation projects more easily. In contrast, many developing countries are in a debt-climate trap, in which high debt levels limit their ability to invest in the infrastructure needed for climate resilience. As shown in Figure 2, countries with limited fiscal space, particularly in the Global South, struggle to expand their adaptive capacity without incurring further debt. Moreover, the failure of advanced nations to mobilise the required climate finance flows has left many of the most vulnerable countries without the necessary resources to invest in critical adaptation projects. Countries with limited adaptive capacity are also those with limited fiscal space.

Figure 2: Adaptive capacity and fiscal space



Source: Own calculations based on IMF and World Bank data. Note: The figure includes 2022 data on 59 low-income countries and their sovereign borrowing space, which is calculated as the difference between the present value of debt as a ratio of GDP at end-2022 and the country-specific present value debt ratio that would put the country at high risk of debt distress, according to the IMF-World Bank LIC-DSF.

The disparity between countries in the Global North and South extends beyond immediate risks. While historically large emitters in the North face lower exposure to climate hazards, the Global South grapples with severe fiscal constraints, heightened exposure risks and growing transition costs. These disparities not only impair their ability to respond effectively to climate risks today but also jeopardise their long-term economic stability and development.

Then, the ability of countries to adapt to climate change is intricately connected to the specific risks they face – whether from high exposure to climate hazards, limited fiscal space or the economic costs of transitioning to greener energy sources. To address these challenges, more robust international cooperation is required, with a particular focus on increasing climate finance and ensuring that countries, particularly in the Global South, have the resources and capabilities to build climate resilience. Bridging the adaptation gap and securing a sustainable future will depend on the global community's willingness to provide the necessary support for all nations to confront the risks associated with climate change.

6.2.3 Economic development and fiscal capacity

Strong macroeconomic and fiscal policies are essential to create a stable economic environment that supports investment in climate mitigation and adaptation. Effective fiscal management, including debt sustainability and public investment, is relevant for creating the fiscal space needed to address the dual challenges of climate change and economic stability.

As the Notre Dame Global Adaptation Initiative (2023) has highlighted, countries that lack fiscal space often have greater climate vulnerability, creating a cycle in which weak fiscal capacity undermines climate-adaptation efforts, which in turn exacerbates vulnerability. In many cases, low-income countries face this dilemma, as they are unable to borrow sufficiently to fund critical infrastructure improvements and climate initiatives, while also confronting high borrowing costs that limit their fiscal capacity even further (Cárdenas and Orozco, 2022).

This relationship is particularly problematic in emerging markets and developing economies (EMDEs). Among this group, countries with high climate vulnerability tend to have lower credit ratings, leading to higher borrowing costs and reduced fiscal space (Cevik and Jalles, 2020). For example, Latin American and Caribbean (LAC) countries, which are especially vulnerable to climate-related disasters, face significant challenges in securing financing for climate adaptation. In the past two decades, these countries have experienced annual economic losses of approximately 1.7 percent of GDP because of climate-related disasters, further straining their public finances and perpetuating their disadvantaged positions in terms of recovering from these shocks (World Bank, 2022). LAC countries also have less access to insurance mechanisms that could mitigate the financial impact of natural disasters. For example, between 2000 and 2021 only 28 percent of the economic damages caused by climate-related disasters in LAC countries were insured, compared to 57 percent in advanced economies (World Bank, 2022). This lack of insurance coverage compounds the economic losses from climate events and increases the fiscal burden on governments.

The fiscal impact of climate change extends beyond the direct costs associated with natural disasters. Transition risks, defined as the economic consequences of shifting towards a low-carbon economy, also place significant pressure on public finances. In regions like LAC, where more than two-thirds of countries depend on extractive industries for export revenue, the transition away from fossil fuels threatens to reduce government revenues, making it difficult for governments to balance fiscal sustainability with investments in green technologies (Delgado *et al*, 2021). For instance, revenues from stranded fossil-fuel assets in LAC are projected to decline by as much as 25 percent to 50 percent of GDP, presenting significant fiscal risks for these economies (Binsted *et al*, 2020).

The decline in oil demand as countries move toward electrification and renewable energy will reduce revenues from fossil fuel exports, potentially leading to severe fiscal shortfalls in countries including Brazil, Mexico and Venezuela (Solano-Rodríguez *et al*, 2021). These countries will need to diversify their economies and implement fiscal reforms to avoid economic disruption during the transition to a low-carbon economy. In these cases, the transition to clean energy presents both challenges and opportunities for economic diversification, but governments must manage fiscal resources carefully to avoid deepening their fiscal vulnerabilities. Effective fiscal strategies can help balance the costs of decarbonisation with the need to maintain public revenues.

Moreover, international cooperation and fiscal support are essential for countries facing severe climate risks but lacking the fiscal capacity to address them. The Inflation Reduction Act (IRA) in the United States has demonstrated how strategic public investment can drive private-sector engagement and accelerate the transition to a low-carbon economy. However, not all countries have the fiscal space to implement similar policies. Low-income and highly indebted countries often lack access to international finance at favourable rates, further limiting their ability to fund necessary climate adaptation and mitigation projects. As a result, these countries rely heavily on international financing mechanisms and grants to support their climate initiatives. The risks of climate change for sovereign bonds have also been highlighted in recent research, underscoring the long-term financial implications for vulnerable nations (Cevik and Jalles, 2020).

Finally, addressing the climate challenges faced by the Global South will require substantial international support, as many of these countries suffer from limited fiscal space, higher borrowing costs and significant climate vulnerability, making it difficult to finance adaptation and mitigation efforts. These fiscal constraints are further exacerbated by the transition away from carbon-intensive industries, creating a cycle in which climate vulnerability leads to economic instability, limiting their ability to invest in climate resilience. International financial institutions and multilateral development banks must provide concessional financing, grants and technical assistance to help these countries meet their climate goals. Without adequate global support, the Global South will struggle to build the resilience needed to withstand the impacts of climate change, widening the inequality gap between high- and low-income nations.

6.3 Climate change and trade policies

The US Inflation Reduction Act (IRA) and the European Union's carbon border adjustment mechanism (CBAM) are key examples of ambitious climate policies designed to reduce carbon emissions in advanced economies. These policies have raised concerns about their potential impact on emerging and developing countries.

The IRA, in particular, allocated nearly $1.4 trillion in federal funding to clean energy development in the United States, with a focus on boosting domestic industrial production of clean-energy technologies, including electric vehicles (EVs). Subsidies are contingent on meeting stringent domestic-content requirements, which effectively exclude many foreign producers. This exclusion risks redirecting investments away from emerging and developing economies rich in natural resources but lacking the technological capacity to compete with the heavily subsidised industries of the Global North (Kleimann, 2023). This situation could exacerbate economic inequalities by limiting the opportunities for developing nations to benefit from the green transition.

The European Union's CBAM is a mechanism designed to address carbon leakage (relocation of activity to jurisdictions without a carbon price), ensuring that efforts to reduce emissions within the EU are not undermined by imports of carbon-intensive goods from countries with weaker environmental regulations. CBAM is part of the larger European Green Deal and Fit-for-55 package, which set targets for reducing greenhouse gas emissions by 55 percent by 2030 and achieving carbon neutrality by 2050.

The core of the EU's decarbonisation strategy lies in structures such as the emissions trading system (ETS), which was launched in 2005 and obliges over 10,000 power plants and factories to hold permits for each metric tonne of CO2 they emit. This system incentivises private-sector investment in low-carbon technologies, aiming to reduce emissions in a cost-effective manner (Cárdenas and Cazzola, 2023). The revised ETS now covers additional sectors such as maritime transport and buildings, and includes the phase-out of free allowances given to heavy industries. The Fit-for-55 package also introduces measures such as binding renewable-energy and energy-efficiency targets, aiming to increase the share of renewables to 42.5 percent by 2030.

CBAM, expected to become fully operational in 2026, is designed to ensure that the carbon pricing applied within the EU is not undermined by external producers. By levying an import charge based on the carbon content of goods, CBAM seeks to encourage producers outside the EU to adopt cleaner technologies (Cárdenas and Cazzola, 2023).

Similarly, although CBAM is part of a broader European strategy, its direct impact on developing countries is significant. Many developing economies rely on exporting carbon-intensive goods – such as steel, cement, aluminum and chemicals – to the EU. The introduction of levies on these goods could reduce their competitiveness in the European market, leading to job losses and economic contraction. The World Bank (2023) highlighted that industries targeted by CBAM are often the backbone of developing countries' economies.

The implications of these policies go beyond direct fossil-fuel industries, extending to service sectors connected to global supply chains. Industries including logistics, finance and insurance, which support the production and consumption of fossil fuels, could also face significant disruptions as the global economy shifts away from carbon-intensive industries. If this transition is not managed carefully, it could exacerbate economic instability, particularly in regions where diversification efforts have not kept pace with declining fossil-fuel revenues (UNCTAD, 2023).

To address these challenges, it is crucial for developing countries to implement social protection measures and retraining programmes to cushion the economic blow. As fossil-fuel revenues decline faster than diversification efforts can replace them, the risk of social unrest increases. Countries that are highly dependent on fossil fuels must adopt robust fiscal management and develop adaptive social-protection systems to mitigate the socio-economic impacts of the energy transition. Failing to do so could lead to further economic instability and more poverty, particularly in regions with high production costs and low levels of diversification (Chepeliev and Corong, 2022).

Adding another layer of complexity is the European Union Deforestation Regulation (EUDR, Regulation (EU) 2023/1115), which requires due diligence on supply chains to ensure compliance with environmental laws. This increases operational costs for exporters in developing countries, particularly for small and medium-sized enterprises (SMEs) that often lack the financial and technical resources to meet these standards. The cost of compliance could result in reduced market access, or even force some SMEs to exit international markets, exacerbating economic vulnerabilities.

Thus, while policies such as the IRA and CBAM represent significant progress toward global decarbonisation, they risk excluding developing countries from the benefits of the green transition. By creating barriers to market access and imposing additional costs on carbon-intensive industries, these policies could undermine economic growth in the Global South. To mitigate these risks, there is an urgent need for international cooperation, increased climate finance and the creation of more equitable mechanisms to manage the global energy transition. Only by ensuring that developing countries have the resources and institutional capacity to participate fully in the green transition can the deepening of global economic inequalities be avoided.

6.4 Conclusion

Addressing the growing divide between the Global North and Global South in the context of climate change requires an approach that integrates both economic and environmental policy. One of the most urgent priorities is the need for enhanced international cooperation to ensure that climate action does not disproportionately disadvantage developing economies. Policies such as the IRA and CBAM, while beneficial for the Global North, risk excluding developing countries from the benefits of the green transition. To mitigate these effects, advanced countries must engage in more inclusive global frameworks that allow for fair access to clean-energy technologies and markets, ensuring that emerging economies are not left behind.

Climate finance is important to bridging this gap. The Green Climate Fund, Adaptation Fund and other international financial mechanisms need to be scaled up significantly to provide developing nations with the necessary resources to adapt to climate risks and build green economies. These funds should not only cover the costs of climate mitigation and adaptation projects but must also help countries diversify their economies away from carbon-intensive industries. Additionally, concessional financing and debt-for-climate swaps can play a pivotal role in allowing debt-strapped nations to invest in climate resilience without exacerbating their fiscal challenges. Without this support, the divide between the economic capacities of developed and developing countries will only widen.

Another critical policy intervention is the development of fair-trade frameworks that prevent green protectionism from further widening global inequalities. The design of mechanisms such as CBAM must account for the economic realities of developing countries. This could involve gradually introducing carbon pricing, tariffs and regulations, alongside compensatory measures such as capacity-building programmes and technology transfers to help developing countries meet green standards without suffering economic setbacks. Creating a differentiated carbon pricing system based on each country's ability to pay and development status would help maintain trade flows while supporting the global decarbonisation agenda.

Finally, initiatives aimed at increasing the adaptive capacity of developing nations are essential. This includes investing in human capital, infrastructure and social-protection systems to help these countries manage the risks associated with the energy transition. Retraining programmes for workers in fossil fuel-dependent sectors, alongside investment in renewable energy and green technology industries, will be key to ensuring that these countries can create alternative employment opportunities and maintain economic stability. Only by addressing these underlying structural inequalities will the global response to climate change be both equitable and effective, limiting the long-term impacts of climate change on the Global South.

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7 Unblocking the flow of capital from rich to developing countries for climate change mitigation

Avinash D Persaud

7.1 Introduction and summary[48]

The planet has a budget for the amount of greenhouse gases it can hold before the probability rises above 50 percent that global temperatures will breach levels that are major tipping points for the planet's biological, chemical and physical systems. We have been using up this budget since the start of the industrial revolution and the acceleration of the burning of fossil fuels for energy and industry. Industrialisation, the economic development of the early industrialisers and rising

48 This chapter is an updated version of the concept paper presented at the G20's Climate Task Force meeting in Belem in July 2024. The ideas presented in this paper were developed in 2017 and are inspired by practical experience and three earlier papers, Persaud, 2023; Martin Wolf, 'The green transition won't happen without financing for developing countries', *The Financial Times*, 30 June 2023; and Caputo Silva and Gragnani (2017). The continued development of this idea would not have been possible without the encouragement of Ilan Goldfajn, President of the Inter-American Development Bank, the collaboration of a team led by Anderson Caputo Silva at the Inter-American Development Bank, support from Rogerio Ceron, Secretary of the National Treasury in the Ministry of Finance in Brazil and the financial support of the UK Government.

emissions went hand-in-hand, and the budget is now 85 percent used up[49]. Industrialised economies, including the former Soviet Union, account for 70 percent of the current stock of emissions or over 50 percent of the budget[50].

Partly in response to global warming and pollution and a resulting shift in industrial activity southwards to developing countries, and partly because of changing consumer spending that comes with high incomes, greenhouse gas emissions from rich countries are stabilising – though at *per-capita* levels inconsistent with staying within the planetary carbon budget if everyone had them[51]. However, this stabilisation is offset by increasing greenhouse gas emissions from developing countries as they industrialise, their young populations expand and their energy use, *per capita*, rises from low and in some cases exceedingly low levels – over a billion people in developing countries are energy poor[52]. Today, 90 percent of the growth in new energy demand and 63 percent of new greenhouse gas emissions are coming from developing countries[53].

49 "*By the end of 2021, the world will collectively have burned through 86% of the carbon budget for a 50–50 probability of staying below 1.5C*", see Simon Evans, 'Which countries are historically responsible for climate change?' *CarbonBrief*, 5 October 2021, https://www.carbonbrief.org/analysis-which-countries-are-historically-responsible-for-climate-change/.

50 North America and Europe have contributed 70.8 percent of cumulative CO2 emissions emitted between 1750 and 2021. Note, this measures CO2 emissions from fossil fuels and industry only. See https://ourworldindata.org/grapher/cumulative-co2-emissions-region.

51 Hannah Ritchie, 'Many countries have decoupled economic growth from CO2 emissions, even if we take offshored production into account', *Our World in Data*, 1 December 2021, https://ourworldindata.org/co2-gdp-decoupling.

52 See Brian Min, Zachary O'Keeffe, Babatunde Abidoye, Kwawu Mensan Gaba, Trevor Monroe, Benjamin Stewart, Kim Baugh, Bruno Sánchez-Andrade Nuño and Riad Meddeb, 'Beyond access: 1.18 billion in energy poverty despite rising electricity access, *Blog*, UNDP, 12 June 2024, https://data.undp.org/blog/1-18-billion-around-the-world-in-energy-poverty.

53 See Jonah Busch, 'Climate Change and Development in Three Charts', *Centre for Global Development*, 18 August 2015, https://www.cgdev.org/media/developing-countries-are-responsible-63-percent-current-carbon-emissions.

There is no longer a workable pathway for the planet to stay below critical climate tipping points that does not include accelerated investment in the green transformation of emerging economies. According to the Independent High Level Expert Group chaired by Vera Songwe and Lord Nicholas Stern, the cost of this investment in climate change mitigation and developing country adaptation needs is over $1.9 trillion per year excluding China. Even with the most optimistic estimates of how much capital emerging markets can mobilise domestically, foreign investors must contribute over $1 trillion yearly of needed climate finance. Yet, capital is not rolling south.

The obstacle is both reflected in, and the result of, the prohibitive cost of capital in developing countries. Green energy projects have low operating costs but require high upfront capital investment. And almost by definition, developing countries are capital short – modest domestic savings are dwarfed by investment needs at the best of times. Even in the largest middle income emerging markets, capital for renewable energy projects costs two or three times more than in developed markets and China, according to the International Energy Agency. The ratio is far higher in other parts of the developing world.

Despite abundant sun and wind, proven technologies and standard contracts, scalable green projects that are commercially viable in developed markets are not so in developing countries. Trying to force the pace of decarbonisation in the developing world through a high carbon price or *de-facto* trade and investment restrictions without lowering the cost of capital first will impose a heavy development burden on the very countries that the planet needs to do more, more quickly, than richer countries have done – even though they contributed least to the problem.

One definition of the cost of capital is the smallest rate of return projects must offer to attract investors away from employing their money elsewhere, in large part as competition for available savings and compensation of savers for risks and their aversion to these risks. Earlier efforts to reduce the cost of capital have focused on mitigating project-specific risks, such as contract, technological and regulatory risks, to make investors more comfortable taking these risks. However, despite these efforts, the cost of capital is still high, and the flow of capital to developing countries is still low. Indeed, current trends have been for capital to flow in the opposite direction.

The flow of capital from where it is plentiful and cheap in developed countries to where it is expensive and in short supply in developing countries is blocked both by the micro risks mentioned in the previous paragraph, but also by systemic, or macro risks, such as risks and uncertainty centred around currency, sovereign credit and political factors. These significantly increase the overall risks of any project to foreign investors. Currency volatility both reflects these risks and contributes to them. And as the currency markets are often the most liquid, they are also often the best place for hedging these macro-risks[54].

Currency risk is an even more critical issue today because unlike extractive commodity projects, renewable energy projects mostly generate local currency revenues. International investors need to convert this local currency revenue into their own currency and face the risk that the exchange rate moves against them. Not everyone hedges, but the scale of investment required means that we need not just emerging market specialist investors prepared to go unhedged, but mainstream institutional investors who hedge as they feel managing emerging market foreign exchange (FX) risk is in neither their interest nor expertise. They prefer to pass on that risk to banks and in return receive a currency-hedged return: a return in their own currency. But the cost of doing so – often in double digits for every year of the hedge – drives

54 Some believe that currency risk cannot be so critical if countries with fixed exchange rates also suffer from a dearth of financial flows. But countries do not end currency risk for foreign investors by committing to a fixed or managed exchange rate regime. The risk merely transitions from the risk of currency fluctuations to the risk and uncertainty that the currency regime proves unsustainable at some point in the future and breaks in an adverse and dramatic way. This may be 'currency devaluation risk' which is larger the longer the period considered.

the currency which has been hedged return below levels that would interest global investors (Persaud, 2023).

If these hedging costs closely reflected actual currency depreciation, there would be little that we could do to lower these costs and unblock investment inflows. However, this is not the case for the largest emerging economies. In a study published by Climate Policy Initiative (Persaud, 2023) taking five of the largest emerging markets (Brazil, India, Indonesia, Mexico and South Africa) and going back every five years for the past twenty years and comparing the costs of taking out a five-year foreign exchange hedge with the actual currency depreciation at the end of each five-year period, the cost of the hedge exceeded the currency depreciation 53 percent of the time and the average excess was a significant 2.7 percent per year (Persaud, 2023)[55]. The study used five-year forward exchange rates as they were the longest for which data was readily available, but the result would be even stronger for longer-dated forwards, like twenty years, the minimum duration of most renewable energy projects.

This '*ex-post* risk premium' rises further to an average of 4.7 percent per year and is positive an amazing 74 percent of the time during five-year periods which start off in periods of market stress (which we can identify as whenever current hedging costs rise significantly above the earlier average) (Persaud, 2023). If reducing hedging costs by as much as 4 percent is within the realms of possibility, as that would raise the currency-protected return by 4 percentage points, say from 5 percent to 9 percent, that would be enough to unblock the flow of finance without the need for public subsidy. To do so we need to address why there is a large *ex-post* risk premium and that it continues.

Where there are no natural or intrinsic offsets for a risk, the holder of a risk must set aside capital as a risk buffer. A critical driver of the high *ex-post* risk premium in FX hedging costs is that those traditionally providing the hedge do not have ready offsets for the risk.

55 This is the average across 372 five-year hedges.

Emerging economies do not issue international reserve currencies, so they are more affected by the international financial cycle. At times of global fright, when worldwide liquidity and risk appetite are in retreat, emerging market currencies come under pressure even without a change in local factors. Markets and consumers then force these governments to limit potentially inflationary currency weakness by tightening fiscal and monetary policies, deepening the economic and financial downcycle. This contrasts with what happens in developed countries faced with a fright, especially those that issue international reserve currencies where governments can 'print money' or run deficits, effectively acting counter-cyclically, limiting the impact of a global shock and speeding up recovery.

We saw this divergent pattern recently in the aftermath of the COVID-19 pandemic. Developed countries expanded monetary policy more than developing countries could, getting to the point where they needed to tighten monetary policy earlier, putting emerging market currencies under pressure. International banks see these divergent risks, but they cannot easily absorb them because they are also subject to the financial cycle – their capital is expensive, their liquidity is short-term, and the risk of falling asset prices also follows the economic cycle. Consequently, when pricing their emerging market currency hedges, they add in buffers for the extra volatility, greater pro-cyclicality and highly concentrated risks. Their regulators also demand that they do so[56]. Finance is structural, not fungible.

In this structure, if we want to reduce the price that banks charge for hedging, we need to reduce the size, maturity and cyclicality of what project promoters or investors ask their banks to hedge. The

56 Insurance and bank regulations often have non-risk-based geography-based capital requirements, like the requirement on European insurers to set aside twice as much capital for risks in non-OECD countries, or four times as much for blended finance transactions compared with risks in OECD countries. We thank Amelie de Montchalin for pointing this out to us.

recently announced Eco Invest Brasil programme[57], developed by the Brazilian government with Inter-American Development Bank support, is an attempt to do so by bringing good sector regulation, stable macro-policy frameworks and the ability of Multilateral Development Banks (MDBs) to lend counter-cyclically to projects onto a single country platform. We propose here a more standardised approach which builds on the FX liquidity facility part of Eco Invest Brasil[58].

To reduce the size, maturity and cyclicality of what projects ask banks to hedge we breakdown the risk in two ways, first by separating out nominal exchange rate weakness from real (inflation-adjusted) exchange rate weakness, and second by separating out extreme plunges in the real exchange rate, leaving more modest, more short-term and more symmetrical cycles in the real rate. When partnering with sustainability projects that are well-regulated and where that regulation allows for long-run cost recovery and for projects to adjust their local prices over some reasonable time, as is already the case in Brazil, we can turn the risk to be hedged from the substantial nominal exchange rate weakness into the more negligible real exchange rate trend.

Moreover, in countries with stable macroeconomic frameworks, such as Brazil's inflation-targeting independent central bank and fiscal-rule-following government, the real exchange rate follows cycles around a stable long-term trend. Then, because of their high credit rating, MDBs can lend counter-cyclically and more long- term to manage the wide cycles around the stable real exchange rate.

In Eco Invest, a pre-arranged commitment by the Inter-American Development Bank to lend dollars at the market exchange rate, but at the MDB's typical lower lending rate and longer maturity in times of market stress, banks manage the remaining risk which is shorter-term,

57 See the official Eco Invest website: https://www.gov.br/tesouronacional/en/sustainable-finance/eco-invest-brasil.

58 For some of the intellectual underpinnings of this product see Persaud (2023), Castro *et al* (2024) and Caputo Silva and Gragnani (2017).

more symmetrical and less pro-cyclical, enabling them to do so without large buffers and thus more cheaply. Our analysis shows that in our group of large middle-income countries under conditions of good regulation and stable macro-policy frameworks, the real exchange rate mean reverts within two to three years of a steep plunge. Many in Brazil will remember the steep devaluation in January 1999, but within two years the real exchange rate had recovered its earlier losses. So, projects can safely repay MDBs over five years, in part through their ability to raise prices in line with inflation and in part through the mean-reversion of the real exchange rate.

By unpacking FX risks in this way for the large emerging economies critical to the planet staying below major climate tipping points, we can dramatically reduce the size, maturity and pro-cyclicality of the exchange rate risk the banks hedge and as a result, dramatically reduce the cost of hedging. By parcelling out risk to where it is better managed, and making the risks left more manageable, there will be a substantial boost in local activity and liquidity. The assurance that this framework offers to investors, projects and banks reduces the cost of capital of projects without subsidy and even before the MDBs extend any lending. And MDBs could, as envisaged in Eco Invest Brasil, lend directly to a government-sponsored structure that then on-lends to eco-projects so that MDBs take on government risk, not project risk.

7.2 The climate finance background

In the introduction we explained that the planet's carbon budget is now 85 percent used up and that developed country emissions *per capita* remain highest, but over 90 percent of new energy demand and 63 percent of new greenhouse gas emissions will come from developing countries. There are only three pathways to remain below critical climate tipping points: (1) substantial degrowth in the developed world, which has its adherents but little political support (2) keeping the energy poor, poor, which has even less support, or (3) a massive shift in how new energy demand in the developing world is generated. As no one is voting for degrowth, and shifting future energy demand is easier than decarbonising existing energy generation, this shift deserves focus. While this path has the added advantage of likely being the best available growth path for developing countries, such a transformation has never been made before at such scale and pace, and we should be in no doubt that the moment calls for much effort and faith from those who did little to bring it about.

7.3 The domestic investment gap

According to the Independent High-Level Expert Group of the 26th, 27th and 28th COP Presidencies, developing countries excluding China need approximately $1.9 trillion in investment per year of the green transformation, a substantial part of which would be for the shift towards renewable energy generation and use (Songwe *et al,* 2022)[59]. What follows focuses on the developing world excluding China because China is atypical. It is the world's largest emitter in total, though middle-ranking in *per-capita* emissions, but it has a large pool of local savings, a low cost of capital and five-year plans that guide investment. It is currently building more renewable energy capacity per year than all other countries put together.

It is often argued by developed countries' officials that we must focus instead on the greater mobilisation of domestic sources in developing countries, such as through the development of savings and investment institutions and the deepening of markets. 'Local currency financing' as it is called, is important, and in the long-run,

59 *"Emerging markets and developing countries other than China will need to spend around $1 trillion per year by 2025 (4.1% of GDP compared with 2.2% in 2019) and around $2.4 trillion per year by 2030 (6.5 % of GDP), on the specific investment and spending priorities identified above. These numbers are based on the analytical work set out in Bhattacharya et al (2022) assessing sector and geographical requirements for investments and actions to keep the target of capping warming at 1.5C in reach and to meet the goals of the Paris Agreement across all its dimensions. The numbers are broadly consistent with the work of the International Energy Agency and the Energy Transition Commission."*

critical. However, the mismatch between the size of the investment needed now and the capacity for local savings to meet those needs is greater than often considered.

Even without a massive shift in energy production and use, developing countries start off being capital short. The $2.4 trillion per year developing countries need for climate investments alone, adding the $1.9 trillion cost of the green transformation with the $500 billion estimated costs of adaptation and climate loss and damage (Songwe *et al*, 2022) represents a large proportion of current domestic savings even before we consider the existing housing, health and education demands on household savings in poor countries. Moreover, the $2.4 trillion estimate appears to be too low today as adaptation costs and loss and damage from inadequate mitigation and adaptation rise. Whatever the exact figure, given the pace and scale needed, investment demands must outstrip local savings requiring foreign direct investment - if it does not, we are not going fast enough.

Even with the most optimistic assumptions on domestic capital mobilisation, the scale of investment needed will require a cross-border flow of close to $1 trillion per year (Bhattacharya *et al,* 2022). This is a major problem. There is, today, little cross-border private investment flow to emerging markets, especially outside of flows to China, India, Mexico and Brazil, and even those flows are inadequate. Total foreign direct investment across all sectors to all developing countries was just $841 billion in 2023, with the bulk of this going to Asia and primarily China and India. Total foreign direct investment to South America, for instance, was just $150 billion, and to sub-Saharan Africa just $36 billion (UNCTAD, 2024).

At the same time, the capacity of developing country governments to borrow overseas is limited – in part by the past and future added budgetary costs of climate-related loss and damage. The Organisation for Economic Co-operation and Development estimates that aid from developed countries, which have plenty of other pressing demands, including a climate-related refugee crisis, is just $200 billion per year and so could not reach a tenth of the climate finance needs discussed here. Tinkering at the edges is not going to work. Something structural needs to change.

7.4 Cost of capital: the obstacle to private investment flows

According to the International Energy Agency, the intermittent generation of energy using solar and wind power has been cheaper than fossil fuels since 2015. However, these technologies are highly capital-intensive. Adding batteries to make renewables capable of replacing and not just supplementing fossil fuels reinforces this capital intensity. In countries where capital is in plentiful supply and not expensive, the long-run superior economics of renewable energies, along with taxes and subsidies, have led to private investment into renewables.

The Climate Policy Initiative estimates that the private sector finances 81 percent of renewable energy investments in the developed world (Buchner *et al,* 2023). But this is not the case in developing countries. There, capital is short, subsidies scarce and the cost of attracting capital from overseas is so high that even switching to standard renewable technologies using standard contracts is unprofitable. Only 14 percent of the current (inadequate) level of investment in renewables is privately financed in developing countries (Buchner *et al*, 2023) .

The cost of capital reflects the smallest rate of return projects have to offer investors to get them to invest. Data on required equity returns from similar solar projects around the world show that while the required equity return is 7 to 9 percent in Europe and the US, in India and Brazil, it is 17 to 22 percent per annum, making it hard for similar projects to be viable. Unless we urgently lower the cost of capital, the green transformation cannot materialise at a sufficient scale and pace. Forcing it through tariffs, high carbon prices, developed-country-level carbon taxes and investment restrictions on non-green activities without lowering the cost of capital will only lead to an overall reduction in already-scarce investment in developing countries, imposing a development penalty on poorer countries that contributed little to the problem.

Up to now, efforts to reduce the cost of capital have focused on reducing micro risks, such as those related to a specific green project, such as contractual, legal, technological and regulatory risks. Much effort has gone into reducing these 'idiosyncratic' risks with standardised contracts and regulations, technology guarantees and agreements to resolve disputes with international arbitration or courts. In this area, the World Bank's Multilateral Investment Guarantee Agency, amongst others, plays a critical role. These efforts are important, but they have still left the cost of capital high and cross-border flows low. This is because macro risks are as great or even greater. Even though this is empirically evidenced, it goes against the theory held by many that the problems with development are poor policies and regulations in developing countries, and not macro or international, so they ignore the numbers.

There is a strikingly strong relationship between the return requirements for renewable-energy investments and country credit ratings, quite irrespective of local prospects, policies and regulations (Buchner *et al*, 2023).

Another way of seeing the equality or even dominance of macro over micro risks is to compare the weighted cost of capital (averaging between debt and equity) between projects and the government cost of borrowing. The government cost of borrowing is a good representation of the cost of country-wide or macro risks, so subtracting the government's borrowing costs from the total project-weighted cost of capital leaves an approximation of the cost of micro risks (Table 1). While these are approximations and deductions, macro risks appear to be at least double micro risks and it is compelling evidence that macro risk factors deserve at least as much attention as micro risk factors. Yet project derisking and micro risk factors often hog all the attention. We must attend to both.

Table 1: Comparative project/sector risks or micro risks (using 2021 annual data) between developed countries and industrialising developing countries

Country category	(1) Weighted cost of capital	(2) Gov cost of borrowing	(3) Project/ sector risk (1) – (2)
Developed countries (represented by the EU as a sample group)	4.0%	-0.3%	4.3%
Industrialising developing countries – sample average	10.6%	7.7%	2.9%
Sample breakdown			
Brazil	13.1%	9.7%	3.4%
India	9.9%	6.3%	3.8%
Indonesia	10.1%	6.2%	3.7%
Mexico	9.7%	6.8%	2.9%
South Africa	10.0%	9.3%	0.7%

Sources: Bloomberg for ten-year government bond rates for 2021 and IEA (2022) for the weighted cost of capital.

7.5 The cost of hedging foreign exchange and macro risks

A high proportion of foreign direct investment in developing countries is in export businesses, including fossil fuels, in large part because the costs and revenues are in US dollars (or another liquid foreign currency), so there is no local currency risk. However, when investors invest in a renewable energy project in a developing country, it is local consumers that are behind the underlying revenue. Eventually, it often makes sense for foreign investors to take the currency risk, not pay hedging costs, and from time to time earn high local currency interest rates. One of the oldest empirical findings in financial markets is this 'forward rate bias.' However, by far the biggest pool of investors are non-emerging market specialists unwilling to take on trading exposures they do not feel expert in.

Further, fair-market accounting and regulatory rules often mean institutional investors such as insurance and pension funds cannot only worry about the long term but must also factor in short-term risks. Consequently, overseas investors avoid unhedged exposure to local currency risk. And if we must attract $1 trillion in investment per year, it is these 'cross-over,' or mainstream, investors who want their returns in their currency, or to hedge their FX risks that we need to attract.

Many countries do not have deep, long-term, forward foreign exchange markets. In many of these countries, Currency Exchange Funds, initially set up by MDBs and development finance institutions, do an excellent job of synthetically replicating the FX market for small investments. However, the countries whose accelerated green transformation will make a planetary difference are sizeable middle-income countries with forward, swap and derivative markets, though they do not go far into the future. For these countries the problem we need to address is more one of market structure than a missing market problem.

7.6 The structural nature of the *ex-post* foreign exchange risk premium

If these FX hedging costs reflect actual risks, then there is little we could do to lower it at the scale we need. However, a background study for this chapter, (Persaud, 2023) on five of the largest emerging economies, going back every five years for the past twenty years and comparing the costs then of taking out a five-year FX hedges and seeing where the exchange rate ended up five years later, revealed that across 372, five-year hedges, the average cost of hedging against currency depreciation was 2.7 percentage points per year more than the actual FX depreciation. This is an average, and the premium can be negative of course. The *ex-post* premium rises to an average of 4.7 percentage points per year and is negative only 26 percent of the time, if the hedge is taken out during the downward or more stressed half of the international financial cycle (Table 2)[60]. These numbers are consistent with

60 A contemporary measure of the downward part of the financial cycle when global liquidity is in retreat is when current FX hedging costs rise above a three or five-year trailing average. The period of the trailing average should be about the length of the typical cycle.

other measures of the emerging market risk premium (Gbohoui *et al,* 2023). If we could reduce this large *ex-post* risk premium, especially during periods of market stress, and boost currency-hedged returns by somewhere close to 4 percent, we could unblock the flow of finance without distortion or subsidy.

The no-subsidy potential of this route is important because it makes this solution more scalable than any other. If the only way to get private financing is through blending it with grants it is unlikely that we will have enough grants before we get close to $1.9 trillion per year of finance. The presence of a large systematic *ex-post* risk premium – the appearance of market participants leaving money on the table – suggests this is a structural issue preventing the achievement of the much smaller *ex-post* risk premiums seen in developed markets.

Table 2: Annual *ex-post* excess risk premium for hedging across the last 25 years and when hedging costs are above the trailing three-year average, using spot versus five-year forwards, five years before

Country	Average *ex-post* risk premium for all periods (annual %)	Average *ex-post* risk premium when hedging costs are greater than the three-year moving average (annual %)
Brazil	4.71%	5.31%
India	1.95%	3.68%
Indonesia	3.18%	5.07%
Mexico	1.54%	4.33%
South Africa	2.2%	3.89%
Group Average	2.72%	4.65%

Notes: We calculated figures for India using the 10-year bond spread with US Treasuries as there is a longer data series than using five-year forwards. For all other countries, we use calculations using spot FX versus five-year forward rates five years before.

A market structure issue most often arises when there is a mismatch between the ability of market participants and the amount of risk they are holding. The less they can absorb the risk naturally, the more they must build in an added-risk premium to absorb it, pushing away demand. There are plenty of intangibles that many cite as a justification for high FX hedging costs that are hard to quantify or nullify as explanations for a high-risk premium, such as poor information, the credibility of institutions, shallowness of markets and rule of law (Gbohoui *et al*, 2023). A stronger, quantifiable, candidate for the structural issue, however, is a market structure issue relating to the extreme pro-cyclicality of emerging market currency risk.

Emerging economies do not issue international reserve currencies, so they follow the international financial cycle with greater amplitude. In times of global fright when global liquidity and risk appetite retreats everywhere, perhaps because of rising interest rates in developed markets, their currencies come under downward pressure even without local fundamentals changing (Kumar and Persaud, 2001). Markets and consumers then pressure their governments to respond to a potentially inflationary currency weakness or to defend weakening currencies by tightening fiscal and monetary policies, deepening a crisis in the near term that started abroad.

The economic slowdown caused by more restrictive policies could increase unemployment. This could raise credit and political risks. Risks that may have started off overseas can quickly become local[61]. All this stands in sharp contrast to some developed countries that can act counter-cyclically, conduct quantitative easing and temporarily run significant fiscal deficits, absorbing and limiting the economic impact and generating speedier recoveries from external shocks.

There is much empirical evidence of the ebb and flow of global liquidity and investor risk appetite on emerging market risk premiums and we saw this very same pattern of divergence of policy responses and results in the immediate aftermath of the COVID-19 pandemic. Indeed, the rapid recovery of those developed countries that were able

61 Reflective of the nexus between the economic cycle and political pressure, there was a spike of 11 coup attempts in 2022 and 2023 in Sub-Saharan Africa in the wake of rising interest rates, debt, and drought.

to respond counter-cyclically in their monetary and fiscal policies to the COVID-induced economic crisis, led to an early return to normal interest rates that complicated the policy environment for developing countries with less counter-cyclical policies and slower recoveries.

International banks have short-term and cyclical liquidity, expensive capital and highly cyclical risks. When they price emerging market currency hedges, they must consider buffers against this extra medium-term volatility and cyclicality. Their regulators demand that they do so, and the capital requirements for exposures to low rated borrowers, or even just those who are not members of the Organisation for Economic Co-operation and Development amplify the costs for banks to deliver these hedges (Griffith-Jones and Persaud, 2008). Life insurers and pension funds with their long-term liabilities may be better at absorbing this extra short-term volatility and cyclicality, but their regulators also often require extra capital for long-term investments in developing countries because of their geography and country credit ratings (Persaud, 2015).

Within this market structure, we can only reduce the cost of hedging if we can reduce the size, maturity and cyclicality of what investors and project promoters need the banks to hedge. Eco Invest Brasil[62] is an attempt to do so by bringing together good sector regulation, a stable macro-policy framework and the ability of MDBs to lend counter-cyclically on a country platform to support climate and nature-positive investments including renewable energy projects, sustainable infrastructure and nature-positive businesses. Building on this recently announced program, particularly the FX Long-Term Liquidity Facility part, we set out below a more standardised version of this approach that MDBs could extend to other countries, MDBs and projects.

62 See the Eco Invest Brasil website: https://www.gov.br/tesouronacional/en/sustainable-finance/eco-invest-brasil.

7.6.1 Reducing hedging costs by reducing the size, cyclicality and asymmetry of what we ask the banks to hedge

From Nominal to Real Exchange Rates

In the long term, inflation differentials are a significant driver of exchange rate depreciation worldwide. Nominal exchange rates fall far more than real (inflation-adjusted) exchange rates[63]. For example, the Brazilian real has fallen over 40 percent in nominal terms against the basket of trading partner currencies since the January 1999 devaluation. The real exchange rate, however, has fallen by less than 5 percent, implying that we can explain almost 90 percent of the long-term weakness of the real by inflation differentials. If we partner then with approved green projects that are well regulated and where that regulation allows projects to achieve cost recovery and adjust their local prices over some reasonable time with local inflation, we can turn the substantial nominal exchange rate risk into the far more modest real exchange rate risk, with the amount to be hedged far smaller.

From long-term downtrend to symmetrical cycles around a stable trend

In countries with stable macroeconomic frameworks, such as Brazil, the real exchange rate follows broad cycles around a stable long-term trend. For example, again, since just before the Brazilian real devaluation of January 1999, the nominal effective exchange rate has never returned to that level, but the real exchange rate returned close to its level just before the devaluation eighteen months later and has spent 50 percent of the last twenty-four years *above* that level. We can see this same pattern in the large emerging market economies with stable macro-policy frameworks alongside rising greenhouse gas emissions.

63 This is why long-term exchange rates are most often estimated using purchasing power parities, which are a measure of relative changes in domestic versus international inflation.

Removing sharp plunges in the downcycle to leave moderate short-term cycles in calmer markets

We can reduce the remaining risks further by breaking down what is left into two parts. There is the part where the real exchange rate plunges below its mean and returns during times of international fright following a ‘V’ pattern below the trend. When we remove these plunges and recoveries from the picture what is left are symmetrical short-term cycles above and below stable trends in calmer waters.

MDBs can make a commitment to provide a pre-determined amount of foreign currency liquidity during plunges in the real exchange rate below its stable trend, at close to the MDB’s borrowing rate and over the long term against project revenues. Projects can repay these loans as the real exchange rate recovers and their prices and revenues rise in line with inflation. In Brazil, we can observe five plunges in the real exchange rate close to 10 percent when the exchange rate was at or below its mean, with the real exchange rate recovering each time between one and three years later (Figure 1), well within the payback period of a five to seven-year loan of foreign currency. The observation that increases in the real exchange rate follow steep plunges is consistent with earlier findings in exchange rate analysis that there is a high average, and overwhelmingly positive, FX risk premium when investors borrow in hard currencies to buy emerging market currencies during the financial and economic ‘downcycle’.

We can use ‘stops’ and ‘limits’ to market exposures to separate the plunges and the symmetrical part of the risk. Projects can hedge the symmetrical part cheaply with local financial institutions and markets. They could even self-insure. It’s cheap because, having stripped out the long downward trend from inflation differentials, stabilised the real exchange rate with a stable macroeconomic framework and removed the steep plunges during the downcycle, the downside risk left for project promoters to manage is short-term, moderate, symmetrical and far cheaper for commercial banks to absorb or layoff than the total risk.

MDBs could lend directly to projects but it is not necessary.

As envisaged in Eco Invest, they could lend directly to a government-guaranteed structure, public development banks or commercial banks that on-lend to eco-projects so that MDBs do not take project risk directly.

7.7 Conclusion

Hedging costs can be reduced by unpacking the risk into parts that are best managed elsewhere and as a result significantly reduce the cost of capital for renewable projects in emerging markets. With projects and regulations managing inflation risks, governments managing macro risks and stabilising the real exchange rate and MDBs playing their natural counter-cyclical and long-term lending role at times of international fright, we can reduce hedging costs. And this could be done without public subsidy, enabling foreign investment flows to be scaled-up to the levels needed. That is the benefit of pulling together the critical players, sustainability projects, sector regulators, finance ministries, central banks and MDBs on one country platform. It brings credibility, liquidity and reassurance to investors. This proposal will not only help unblock the flow of foreign and local investors to the green transformation of emerging economies but also increase the liquidity of local financial markets and critically reinforce and reward the benefits of good sector regulation and stable macro-frameworks.

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8 Promoting China-Europe Cooperation on Climate Change

Zhou Xiaochuan[64]

8.1 Introduction

In the last two decades, China and the European Union have become among each other's most important trading partners, with their bilateral cooperation spanning a wide spectrum and yielding significant results. However, heightened geopolitical conflicts, economic security concerns and escalated trade protectionism have posed major challenges to this crucial relationship. Despite these difficulties, consensus can be found to address daunting global challenges, including climate change, global public health crises and governance of artificial intelligence. Additionally, third-party market collaboration remains an important domain. Among these areas, close cooperation on climate change can provide crucial impetus for the China-Europe relationship. To further this collaboration, six issues should be thought over (sections 8.2 to 8.7).

64 This chapter is based on a speech given by Zhou Xiaochuan at a Bruegel closed-door event in Brussels on 19 June 2024.

8.2 Substantial gaps remain in tackling climate change

While many countries have made and started to implement pledges to address climate change, substantial gaps remain in both the actions taken and the financing required to stay within the temperature increase limits set out in the Paris Agreement.

The United Nations Framework Convention on Climate Change's report *Nationally determined contributions under the Paris Agreement*, issued at the COP28 climate summit in December 2023, found that, assuming full implementation of the 168 nationally determined contributions (NDCs; countries' climate pledges) available by September 2023, the ambition gap is 11.6 (7.6–15.1) gigatons of carbon dioxide equivalent (GtCO2e) by 2030 for global warming to stay within 2 degrees Celsius above pre-industrial levels, and 19.5 (17.8–24.4) GtCO2e to stay within 1.5°C (UNFCCC, 2023). Therefore, emission reductions up to 2030 will have to be further enhanced for 2035 and beyond. To limit warming to 1.5°C, global greenhouse gas emissions need to be reduced by 60 (49–77) percent by 2035, relative to the 2019 level. In the 2°C scenario, emissions in 2035 need to be 37 (21–59) percent below the 2019 level.

According to data from BloombergNEF, in a net-zero 2050 scenario, a $3 trillion investment gap is forecasted for the global energy transition. Among the major sectors, the most significant financing shortfalls are observed in electrified transport, renewable energy (particularly solar, wind and nuclear), the electricity grid and carbon capture and storage. Currently, only about half of the targeted investment amount has been secured for some of these sectors, with certain areas lagging even further, with only one-third of the required funding. Collaborative efforts among nations in these areas are urgently needed to bolster climate financing initiatives.

Table 1: Investment gap by sector ($ billions)

	2023 investment	Required annual investment for net zero*, 2024-2030	Investment gap
Electrified transport	$632	$1,805	$1,173
Renewable energy	$623	$1,317	$694
Electricity grids	$310	$700	$390
Electrified heat	$63	$50	-$13
Clean industry	$49	$21	-$28
Energy storage	$36	$93	$57
Nuclear energy	$33	$284	$251
Carbon Capture and Storage (CCS)	$11	$510	$499
Hydrogen	$10	$62	$52
Total	$1,767	$4,842	$3,075

Source: BloombergNEF. Note: *BloombergNEF's Net-Zero 2050 Scenario

8.3 China's net-zero roadmap

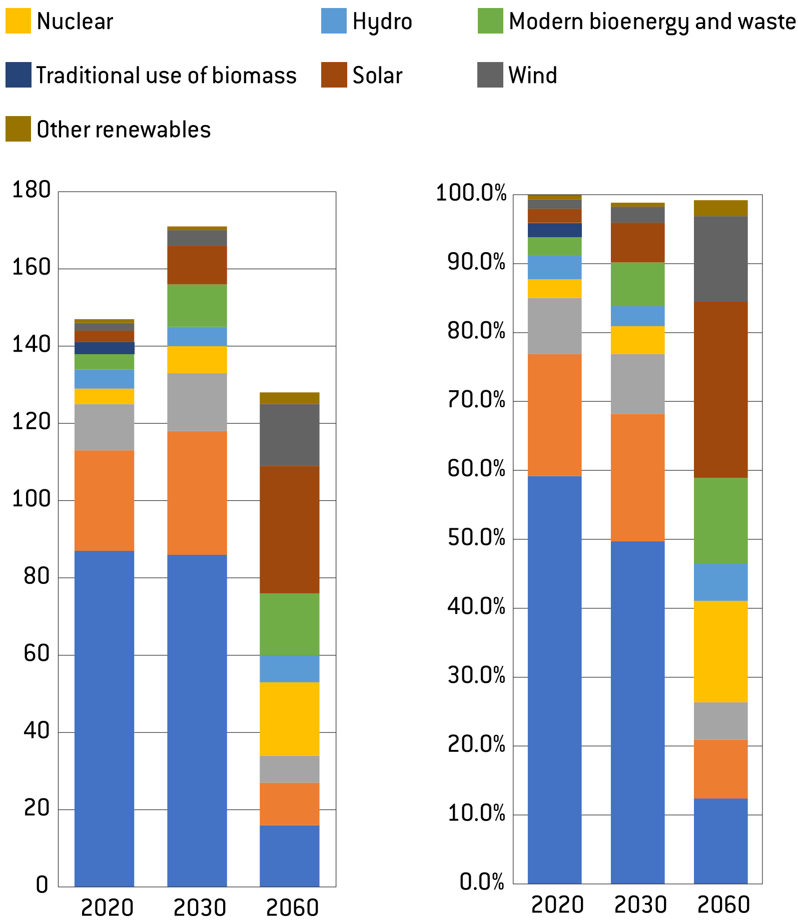
China set out its '3060' dual carbon targets in 2020, referring to a carbon peak before 2030 and carbon neutrality by 2060. According to its roadmap, tremendous efforts will be made in both energy conservation and carbon reduction. China's State Council has released an *Action Plan for Energy Conservation and Carbon Reduction for*

2024-25[65]. Technological advancement will continue to play a key role on this journey, including developments in solar, battery and other energy storage, and in grid infrastructure and operation.

From Figure 1, it is evident that, according to the IEA, the share of fossil fuels in China's energy mix will decrease from the 85 percent in 2020 to 77 percent in 2030, and further down to 26 percent in 2060. In contrast, the share of solar and wind in the energy mix would increase from 2.0 percent and 1.4 percent respectively in 2020 to 5.8 percent and 2.3 percent in 2030, and further up to 25.6 percent and 12.4 percent in 2060. Hydro and modern bioenergy and waste are also expected to grow from 3.4 percent and 2.7 percent respectively in 2020 to 5.4 percent and 12.4 percent in 2060 (IEA, 2021). Thus, to realise its '3060' goals, China needs to intensify its endeavours in key areas including solar power, wind energy and smart-grid development.

65 See State Council of the People's Republic of China news of 29 May 2024, 'China to take action for energy conservation, carbon reduction', https://english.www.gov.cn/policies/latestreleases/202405/29/content_WS66570ed0c6d0868f4e8e79d0.html.

Figure 1: Primary energy demand by fuel in China (in EJ-left and in %-right)



Source: IEA and BFA.

After the first global stocktake in 2023, all parties to the UNFCCC are expected to update and enhance their NDCs. In the case of China, the 26 percent fossil-fuel share in power generation by 2060, as estimated by the IEA, does not sufficiently reflect China's ambition. Measured by international comparative energy components, this figure could be further reduced by half or three-quarters by 2060, as demonstrated in the enhanced scenario in Figure 1. The remaining portion of carbon emission will be offset by carbon capture and storage technologies and increased carbon sinks.

8.4 The cleantech overcapacity debate

With China's cleantech manufacturing showing significant growth and momentum in the past few years, debate on China's cleantech overcapacity has been heated and captured widespread global attention. The argument that China's solar, wind-power and battery-storage capacities exceed both domestic and international demand is based on several misunderstandings.

First, the replacement ratio of traditional fossil-fuel installed capacity to wind and solar installed capacity is not 1:1. These power sources differ in nature, require different transmission conditions and vary significantly in annual operating hours. Hence, it requires at least several times the installed capacity of wind and solar power generation to replace traditional fossil-fuel power capacity.

Second, some calculations do not correctly factor in the potential increase in power demand. Considering GDP growth rates and escalating electrification, the power demand of developing countries, including China, is projected to increase to at least two to 2.5 times its current level by 2050 or 2060.

Third, the proportion of fossil fuel in electricity generation could be lowered under the enhanced net-zero scenario. As mentioned earlier, the current target is that, by 2060, 26 percent of China's electricity generation would come from fossil fuel, which some experts view as not bold enough. China is working on its NDC update with more ambitious pledges.

Fourth, while China pledges to achieve carbon neutrality by 2060, there are numerous international calls urging China to accelerate its efforts and move that target forward by 10 years. The 2050 narrative would require a substantial surge in the demand for solar and wind energy equipment and installation in China.

Fifth, the lifecycles of new energy equipment need to be assessed more reasonably, along with their replacement demands. At the present stage in China, many suppliers claim that the service life of photovoltaic and wind turbine equipment can be up to 20 years. However, users have reported significant declines in photovoltaic conversion efficiency, necessitating the acceleration of component replacement. The lifespan of lithium batteries in electric vehicles is much shorter, requiring more frequent replacements. That said, anticipated future replacements of new energy equipment are expected to double the production demand.

Given all the above factors, the assertion of overcapacity in China's new energy manufacturing lacks proper calculation support.

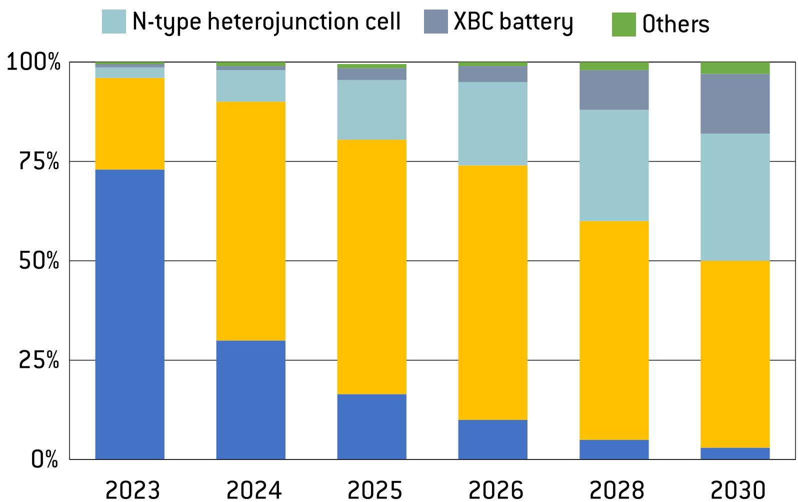
It is noteworthy that, since late 2023, several Chinese provinces have suspended new wind and solar energy projects. This was because the grids are not upgraded quickly enough and are not smart enough to cope with the surge of power supply from the new energy sources. However, this is only a temporary phenomenon. Efforts are underway to address this shortfall. China is studying European experiences and gradually establishing price-incentive mechanisms to improve grid infrastructure, including development and construction of smart grids and microgrid systems.

In addition, regarding international demand for cleantech manufacturing, it is important to recognise that continents and regions with large populations, such as Africa, the Middle East and Southeast Asia, are in the process of industrialisation and their electricity consumption is expected to rise significantly. As a result, most developing countries in these regions are encountering massive pressure on decarbonisation, and can be expected to have genuine enormous demand for cost-effective cleantech equipment. China is willing to leverage its existing technology, equipment and manufacturing capacity to assist these countries, in particular in constructing their national and regional power systems for mutual benefits and as part of global climate actions.

8.5 Technological competitiveness

The competition in new energy technology has intensified among major economic powers, with technology rapidly being upgraded and equipment being renewed. An observation is that, even for advanced economies including the United States, European countries, Japan and South Korea, renewable energy technologies, especially in solar and wind power, are not politically or militarily sensitive. Take battery technology, for example, which has advanced very swiftly (Figure 2). In 2023, p-type batteries accounted for over 70 percent of the market share, but n-type batteries surpassed them in 2024. Current research and development in batteries focuses on entirely different technologies, such as solid-state batteries. If a country were to invest in developing the same battery technology as a means to enhance its competitive edge, that technology might quickly become outdated, resulting in a net loss. The optimal strategy is to leapfrog in competition, that is, to lead in the research and development of the next generation of battery technology.

Figure 2: Market share of different battery technologies, 2023-2030



Source: China Photovoltaic Industry Association (CPIA).

The breakthrough and scaling up of clean technologies can help harness desert energy in the Middle East and North Africa, and subsequently to supply electricity southward to African countries and northward to Europe. Two decades ago, the 'Desertec' project, aiming at developing solar and wind power at large scale in the desert in Middle East and North Africa and transmitting electricity to Europe, was found to be not feasible[66]. However, with advancements in technologies such as solar photovoltaics, concentrated solar power and large-scale hydrogen storage and power generation, and substantial cost reduction of these technologies, the Gulf Cooperation Council (GCC) countries and selected North African nations are now able to harness local solar and wind energy more efficiently. The technology of ultra-high-voltage power transmission can empower them to transmit desert energy both to Africa and Europe.

8.6 China-Europe climate-finance cooperation

Together with multilateral development banks (MDBs), major long-term investors in China and Europe can play a key role in channelling capital towards the green transition. China's high savings rate can be further leveraged. The China Development Bank, the Export-Import Bank of China, the China Investment Corporation and the Silk Road Fund have been pivotal in this endeavour. Sovereign wealth funds and pension funds in Europe, such as Norges Bank Investment Management, APG and PGGM, have all actively engaged in green investment. Long-term investors from both sides can enhance collaboration to amplify impacts.

MDBs including the European Investment Bank, the European Bank for Reconstruction and Development, the Asian Development Bank and the Asian Infrastructure Investment Bank, can be a crucial bridge to link major long-term investors and help catalyse and

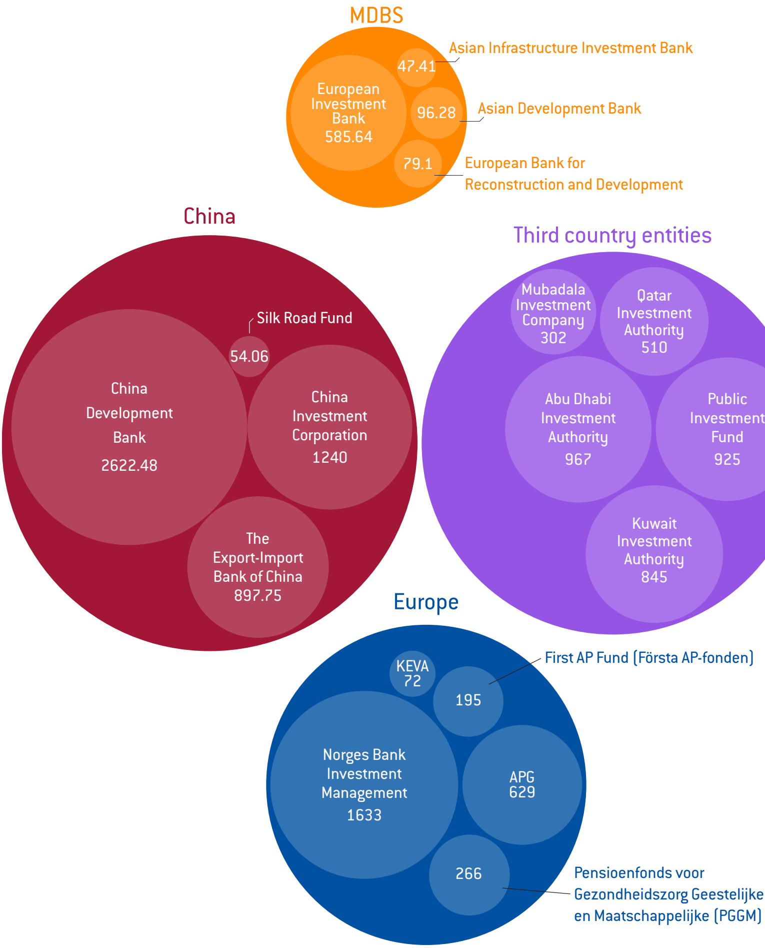
66 See for example *Euractiv*, 'Desertec abandons Sahara solar power export dream,' 31 May 2013, https://www.euractiv.com/section/trade-society/news/desertec-abandons-sahara-solar-power-export-dream/.

mobilise substantial climate funds from the private sectors in both China and Europe.

Furthermore, China and Europe can join forces in investing in third-party markets and partnering with sovereign wealth funds, such as those from the GCC countries, to promote energy transitions and confront climate-change challenges.

In addition, China has studied and gained a lot from Europe's rich experiences in its carbon allowance trading system, the EU emissions trading system, which has effectively incentivised substantial decarbonisation actions, innovation and investment. The dialogue and knowledge sharing in this domain should continue.

Figure 3: China-Europe climate-finance collaboration ($ billions)



Source: BFA Academy.

8.7 Better use of CBAM revenue

While the carbon border adjustment mechanism (CBAM) put in place by the EU as of 2023 aims to address the issue of carbon leakage, many developing countries are concerned about its trade protectionist motivations. The EU could consider transparently reorienting the revenues from CBAM to purchase carbon credits from exporting countries or emerging markets. This approach would not only fulfil the commitment of developed economies to provide $100 billion annually in climate aid to developing countries, but would also demonstrate that that CBAM is indeed intended to support global efforts in climate mitigation and adaptation, rather than to boost the EU's own fiscal revenues. By adopting this approach, the EU may elicit positive responses from developing countries.

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9 The supply side of the green transition: economy of scale, competition and international trade

Wensheng Peng

9.1 Achieving the green transition

There are two main ways to achieve a green transition: reducing fossil-fuel demand by pricing carbon emissions (through mechanisms such as carbon markets and taxes), and increasing clean energy supply by supporting research and development and fostering clean-energy industries. The first approach targets the correction of negative externalities, while the second focuses on internalising the positive externalities of innovation. But which is more effective? A crucial, often overlooked factor is the economies of scale on the supply side, which are particularly relevant to three characteristics of the clean-energy industry:

1. Its manufacturing nature, which inherently benefits from economies of scale;
2. Its digital components, which amplify the scale effects of manufacturing; and
3. Its demand for land, which can lead to diseconomies of scale – an issue that could be mitigated more effectively in spatially large countries.

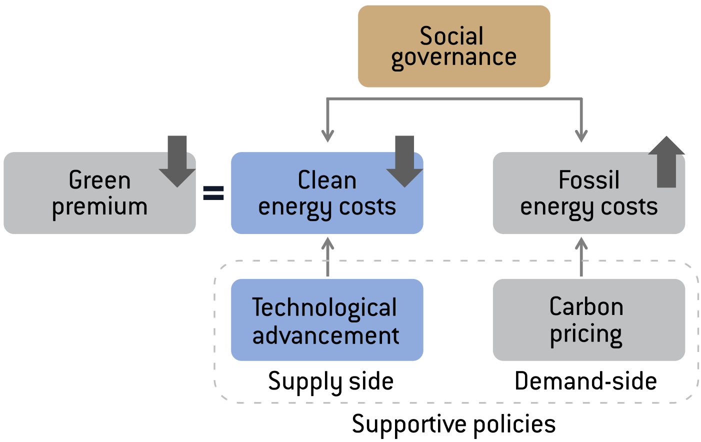
Another significant aspect of the supply side of the clean-energy industry is the rise in competition, which increases the efficiency of global production and may also lead to a shift in the global trade landscape, including through a rise in green protectionism. China, with its scale advantages in manufacturing, digitalisation and available physical space, is driving the rapid development of green industries. But challenges remain, including the lack of systematic governance over land use for clean energy and signs of increasing green protectionism. To address these challenges, China should adopt policies that help promote green technology innovation, while strengthening regional and international trade ties to foster a trade environment more friendly to the global green transition.

9.2 Two different approaches to reduce the green premium

The significance of the green transition is self-evident. How can the progress of the green transition in China and around the world be understood from an economic perspective? CICC (2022) delved into the economics of green transition and dissected a key formula – the green premium is equal to clean-energy costs minus fossil-energy costs. Lowering the green premium is the key to reducing carbon emissions (ie the switch from fossil energy to clean energy).

How can the green premium turn negative? The first approach is to raise the cost of carbon emissions through carbon pricing, including by levying carbon taxes and trading in carbon emission allowances. Carbon pricing is a new paradigm that requires government intervention to correct the negative externality of carbon emissions – the release of carbon emissions benefits individual emitters but harms society or even the world as a whole (Li *et al*, 2022). To internalise the social costs arising from this negative externality, individual carbon emitters should pay for their emissions. However, carbon pricing has a consequence. It hinders economic growth, at least in the short term (Chipalkatti, 2019). There is also considerable controversy about the fairness of carbon pricing as developed countries emitted vast volumes of greenhouse gases in the past, but require developing countries to cut emissions at present by raising the cost of carbon (Simpa *et al*, 2024).

Figure 1: Green premium = clean energy costs – fossil energy costs



Source: CICC (2022).

The second way to reduce the green premium is to lower the cost of clean energy through technological innovation and progress (Raghutla and Chittedi, 2023). It is important to note that technological innovation and progress also bring externalities, but such externalities are positive. In other words, technological innovation requires investment from individuals but technological progress benefits the whole society. Without proper intervention, the sum of individual investment in technological innovation would be lower than the ideal level for the whole society (He *et al*, 2023). Therefore, the government should step in to encourage individual investment in innovation by providing subsidies or through other institutional policies.

In summary, there are two main approaches to green-premium reduction: the demand-side approach of lowering demand for fossil energy through carbon pricing, and the supply-side approach of slashing the production cost of clean energy via technological progress. Major economies differ in their choices between these two approaches.

9.3 Focus on the supply-side approach is growing

China has relied primarily on the supply-side approach to green-premium reduction, for example through its feed-in-tariff scheme for wind and solar power producers and supportive policies for the energy-storage sector and the new-energy vehicle (NEV) industry chain (Song *et al*, 2023). The central government implemented the feed-in-tariff scheme for wind and solar power producers from 2009 to 2021. Wind and solar-power producers with certain technologies have now achieved grid parity and no longer rely on subsidies. Supportive policies for the energy-storage sector include mandatory requirements on the construction of energy-storage facilities at a certain percentage of the installed capacity of renewable energy producers, and expediting the optimisation of a time-of-use electricity-pricing system. The NEV industry chain also received fiscal support from central and local governments, including government procurement and exemptions from purchase taxes.

In contrast, the European Union previously focused mainly on the demand side, leveraging its carbon market to reduce fossil-energy consumption (Yang *et al*, 2023). In 2023, the EU's carbon market set a more ambitious emissions-reduction goal for relevant sectors, requesting that they cut total emissions by 62 percent by 2030 from 2005 levels. In comparison, the previous emissions-reduction target was only 43 percent below 2005 levels. Carbon prices in the EU's carbon market have climbed to €80–€100 per tonne of CO_2 emissions, well above the average carbon price in China (less than 60 renminbi per tonne of CO_2 emissions). However, a noteworthy new trend has emerged over the past two years: the EU and the US (especially the latter) have turned to a supply-side approach to reduce the green premium.

In August 2022, US President Joe Biden signed the Inflation

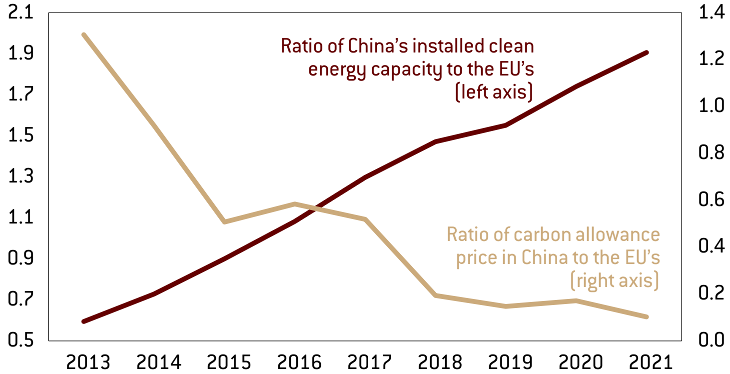
Reduction Act (IRA) into law, creating a wide range of supply-side incentives. In many cases, the IRA requires products eligible for incentives to satisfy certain domestic content requirements, such as production in the US. In addition, the IRA planned to make $369 billion worth of green investment in response to climate change and to enhance energy security (Ragonnaud, 2024). Furthermore, cash subsidies or tax credits will cover 30 percent to 50 percent and 50 percent to 70 percent respectively of the production costs of photovoltaic (PV) modules and lithium-ion batteries in end markets[67]. The EU, meanwhile, has adopted the Net Zero Industry Act (Regulation (EU) 2024/1735), to ensure that *"the manufacturing capacity in the Union of the strategic net-zero technologies … approaches or reaches at least 40% of the Union's annual deployment needs"* (Ragonnaud, 2024).

Let's compare the effects of the two different approaches to the green transition since 2013. We have found that the ratio of China's carbon price to the EU price has declined and fell below one in 2014, which indicates that China's main green-transition tool is not carbon pricing. However, since 2015, the ratio of China's installed clean-energy capacity compared to the EU's has been greater than one and has continued to rise rapidly.

These figures show that China's supply-side industrial policies were quite effective in driving technological progress and expansion of clean-energy capacity. Although headwinds facing China's economy have caused concern for some time, a few bright spots can still be seen, the largest of which is the country's NEV industry.

67 Source: CICC Research estimates.

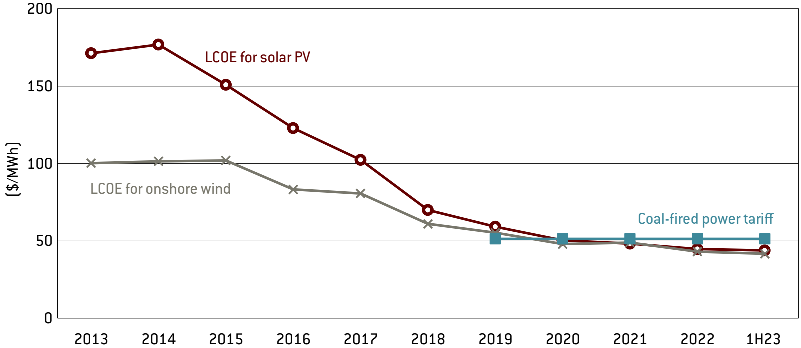
Figure 2: Ratio of China's installed clean-energy capacity to the EU's vs. ratio of China's carbon price to that in the EU: moving in opposite directions over the past decade



Source: BloombergNEF, Wind, CICC Global Institute. Note: the carbon market price in China is the average price in nationwide and regional markets. The installed clean energy capacity is the sum of cumulative wind and solar installed capacity.

Have China's various policies effectively reduced the green premium? We compared the levelised costs of energy (LCOE) for solar PV and onshore wind power with the coal-fired power tariff in China, and found that the green premium is already negative in China, and its absolute value is increasing gradually. Therefore, the answer to the above question is that China's policies have effectively turned the green premium negative, which means the price of electricity generated from clean-energy sources is lower than the price of fossil-fuel energy in China.

Figure 3: The green premium in Chinese power generation has turned negative

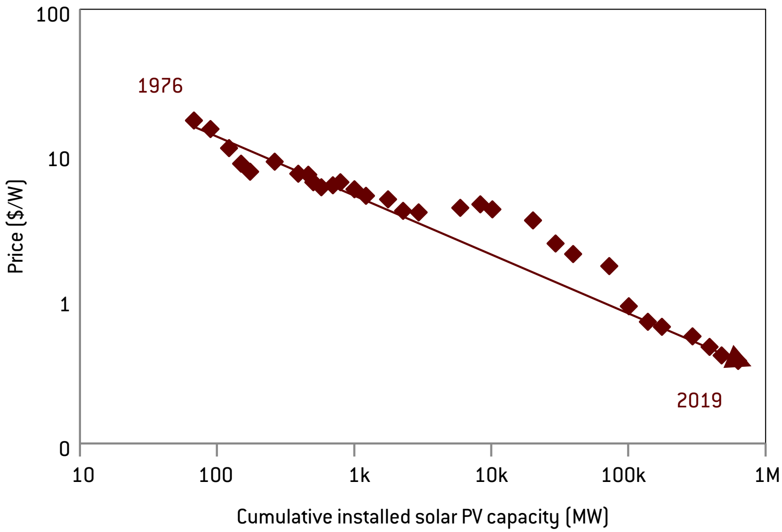


Source: BloombergNEF, Provincial Development and Reform Commissions, CICC Global Institute. Note: in this chart, the data for solar PV is the LCOE of fixed-axis PV systems, the LCOE per kWh of solar power and onshore wind power is the national average, and the coal-fired power tariff is the median of various provinces.

9.4 Driving China's green premium down: economies of scale

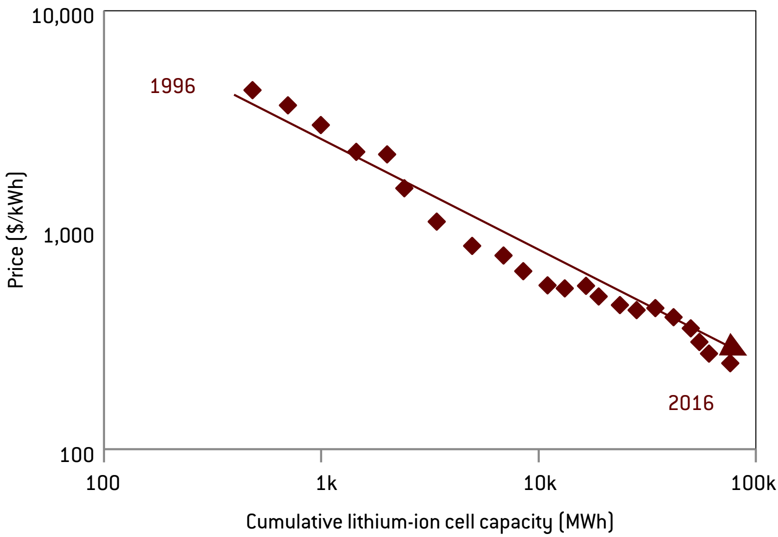
Why is the supply-side approach more effective in reducing clean-energy costs and lowering the overall green premium, as observed in China? The key factor is economies of scale. At the company level, economies of scale occur when production costs are spread over a larger number of products. This is especially true in manufacturing sectors, which typically have proportionally larger fixed costs that can be amortised over greater output. The new energy industry resembles manufacturing more than the fossil-fuel industry, which is heavily resource-dependent. This industry has already shown strong scale advantages. For example, between 1976 and 2019, the price of PV modules dropped by an average of 20 percent each time global installed PV capacity doubled (de La Tour *et al*, 2013). Similarly, between 1996 and 2016, the price of lithium batteries fell by an average of 19 percent every time the scale of lithium battery installations doubled (Ziegler and Trancik, 2021).

Figure 4: Learning curve of solar modules



Source: Our World in Data, CICC Global Institute

Figure 5: Learning curve of lithium-ion batteries

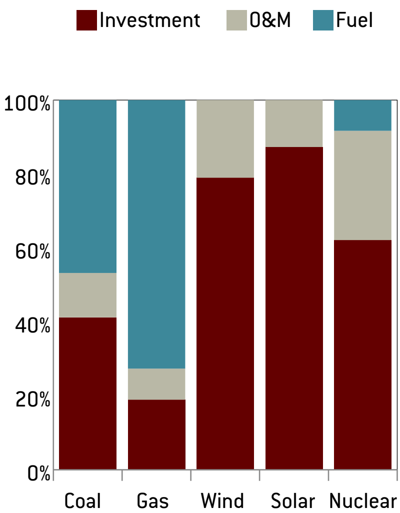


Source: Our World in Data, CICC Global Institute

At the macro level, economies of scale can be achieved when population or market size expands, allowing for greater division of labour and improved economic efficiency. China's scale advantage arises from its large population, substantial market size and high level of economic diversification.

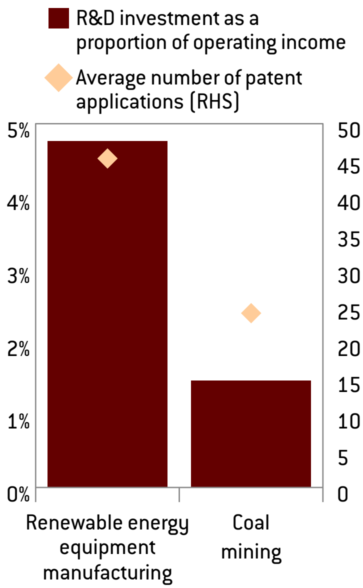
Specifically, strong scale effects in the clean-energy industry are primarily related to three types of fixed costs, which can be widely distributed and significantly reduced as production expands.

Figure 6: Cost composition of different power generation technologies



Source: Hirth (2016), CICC Global Institute. Note: O&M = operation & maintenance. Equipment costs account for most investment costs.

Figure 7: Renewable energy equipment manufacturing industry is technology-intensive



Source: iFinD, CNIPA, CICC Global Institute. Note: Renewable energy equipment includes wind power equipment, photovoltaic equipment and lithium batteries. Data is based on A-share listed companies in 2022.

First is the equipment cost, which constitutes a much larger share of total production costs in the clean-energy industry compared to the fossil-energy industry, in which fuel costs, seen as variable costs, dominate. For instance, fuel-input costs for coal and gas power account for about 40 percent to 70 percent of the total power-generation cost. In contrast, investment costs, such as equipment costs, for new energy power generation, account for more than 80 percent. This indicates that new energy power generation relies more on equipment manufacturing, while fossil energy power generation depends more on resource availability.

The second cost is R&D cost. Manufacturing clean-energy equipment is a technology-intensive process, requiring sizable amounts of R&D investment. We note that in China, A-share listed companies in new energy equipment manufacturing, such as lithium-ion batteries, photovoltaic and wind power, spent almost 5 percent of their annual revenues on R&D in 2022, with some leading companies even spending more than 7 percent. This is much higher than the 1.5 percent spent by coal-mining enterprises. Similar gap exists between these two groups of companies when it comes to the number of annual patent applications.

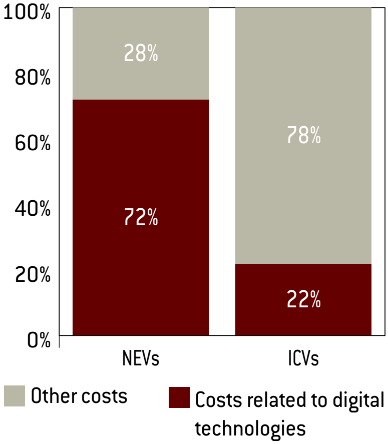
The third cost is related to infrastructure. Infrastructure shows strong economies of scale, and this could be even more important for the clean-energy industry. For example, in most cases, places with abundant wind and solar resources are likely in remote areas and therefore require long-distance and ultra-high voltage (UHV) transmission lines. In China, for example, the investment per unit length of UHV transmission lines of 800kV and above is 15.4 million renminbi/km, which is much higher than the 3.7 million renminbi/km of 220kV traditional transmission lines. Moreover, to connect more distributed solar power generation, smarter and more flexible distribution lines are needed in the power system, which requires significant amounts of investment.

9.5 Digitalisation is amplifying economies of scale

Digitalisation has further amplified the economies of scale in China's new energy industry. This includes both internal and external economies of scale. Internal economies of scale reduce production costs within an individual firm, a phenomenon more prevalent in clean-energy manufacturing than in traditional manufacturing sectors (Liu *et al*, 2022). For instance, digital technology costs in NEVs account for an average of three-quarters of the total vehicle cost, compared to only one-quarter for internal combustion vehicles (ICVs). Data, a key production factor in the digital economy, can be replicated at low or even zero cost, often resulting in stronger scale effects than in other industries. When data is utilised in production, it can enhance the efficiency of other production factors, including capital and labour, thereby reducing marginal production costs and amplifying the scale effect in manufacturing (Li and Xie, 2022).

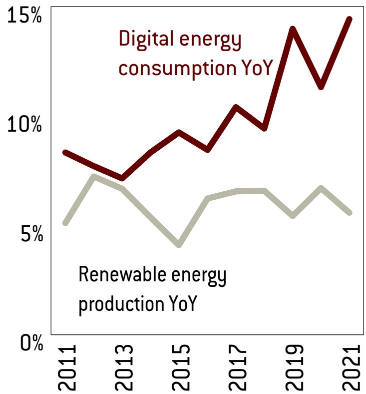
The digital economy also enhances external economies of scale, which occur outside of individual companies but within the same industry. In the green economy, digital networks can connect more terminals for green services, such as EV charging stations, reduce information asymmetry and expand the network capacity of green industries. As digital network entities generate more data, they can provide more information to improve search and matching efficiency, attracting more entities and strengthening external scale effects and network effects. Additionally, the application of digital technologies has promoted modular production in manufacturing, enhancing the scale effect through a deepened division of labour. Large countries are more likely to have relatively complete industrial systems and a greater number of production modules, further amplifying the scale effect.

Figure 8: Proportion of costs related to digital technologies in NEVs and ICVs in 2021



Source: Autohome.com, CICC Research, CICC Global Institute.

Figure 9: Global growth rate of digital energy consumption and renewable energy production



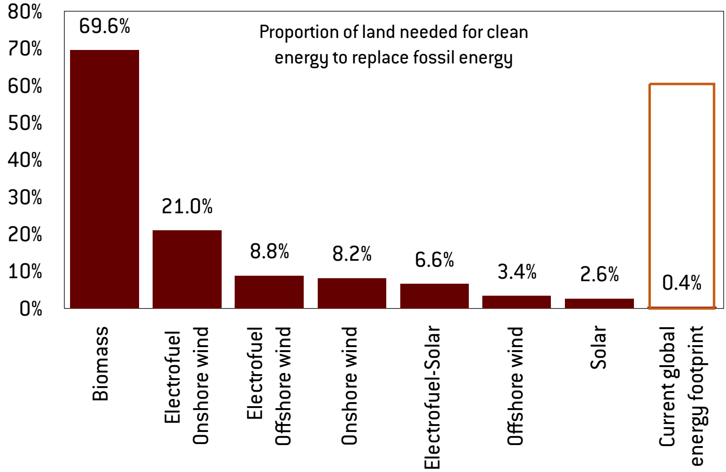
Source: DOE, Our World in Data, CICC Global Institute.

9.6 Diseconomies of scale for land use: large countries could do better

As mentioned previously, economies of scale refer to the reduction of average costs or the increase in average output as inputs increase. The new energy industry benefits from economies of scale. However, renewable power generation per unit of land does not increase with additional land use. With technology levels remaining unchanged, total renewable power generation can only be increased by expanding land use, which exhibits typical diseconomies of scale.

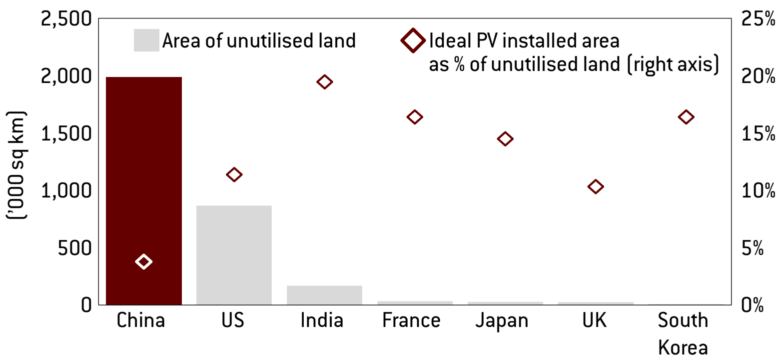
As a result, the green transition significantly increases the demand for land. It is estimated that the current global energy system occupies only 0.4 percent of ice-free land, while at least 2.6 percent would be needed to replace the current energy system with clean energy – an area almost the size of India. This competition for land use can lead to a rise in land cost for other economic activities, causing increases in food prices, conflicts between landlords and farmers, and loss of biodiversity. These diseconomies of scale in land use may hinder the development of economies of scale in the clean-energy industry and bring about risks to the broader economy.

Figure 10: Realising green transformation requires a large amount of land



Source: Rennuit-Mortensen *et al* (2023), Lovering *et al.* (2022), CICC Global Institute.

Figure 11: China is relatively rich in unutilised land



Source: China Ministry of Natural Resources, BLM, Global Land30, CICC Global Institute. Note: The data for China is 2019, and the ideal PV installed area is calculated based on the assumption of 1% of the land area.

Since land exhibits diseconomies of scale, large countries with more extensive land areas are better positioned to overcome these challenges. The spatial advantage of large countries lies in their ability to find land for renewable energy without encroaching on land used for other uses, particularly food production.

China has a significant advantage in this regard, with vast amounts of underutilised land. Its deserts and sandy lands, primarily located in the five northwest provinces and the Inner Mongolia Autonomous Region, are rich in solar energy. Assuming that achieving carbon neutrality in China requires constructing 10 billion kW of PV capacity, the corresponding area would be about 150,000-200,000 square kilometres. This is still only a small fraction of China's deserts, sandy lands and other unused areas. In contrast, other large countries such as the US and India, as well as smaller countries, have relatively limited unused land resources.

9.7 Transforming the energy industry landscape and international trade

The clean-energy and fossil-fuel industries have distinct production characteristics. Clean energy primarily harnesses renewable natural resources, while fossil fuels rely on non-renewable mineral resources. This fundamental difference leads to varying levels of monopolistic power based on the exclusivity of resource ownership. When entities have exclusive rights to critical production resources, preventing others from accessing alternatives, they gain monopolistic power. This exclusivity is largely determined by the ownership of natural resources and the exclusivity of production equipment and technology.

Renewable natural resources, such as wind and solar, are widely distributed across the globe, making exclusive ownership impossible. In contrast, fossil-fuel resources are concentrated in specific areas, allowing for exclusive appropriation by certain countries. In relation to production equipment and technology, renewable resources are generally accessible at or near the Earth's surface, with no significant physical differences across regions. This allows for standardised equipment design and manufacturing, making clean-energy technology relatively easy to acquire with a lower degree of exclusivity. Fossil fuels, however, are often buried deep underground, and each extraction site has unique geological and environmental conditions, requiring customised equipment and solutions. This results in a higher degree of exclusivity in fossil-fuel equipment and technology.

These differences in exclusivity lead to significant disparities in the monopolistic characteristics of the renewable-energy and fossil-fuel industries, causing substantial shifts in the energy industry structure during the green transition. The fossil-fuel industry, characterised by the extraction of and trade in mineral resources including oil, natural gas and coal, is highly monopolised (Norouzi and Fani, 2021). A few countries typically extract these resources and transport them internationally for consumption. In contrast, clean-energy resources, because of their widespread availability and difficulty in storage and transportation, are more suitable for local collection and consumption. The clean-energy industry primarily involves the trade in equipment, such as photovoltaic devices and wind turbines, highlighting its manufacturing nature. Unlike resource extraction, manufacturing is less influenced by monopolistic power derived from natural conditions. Consequently, while the competitiveness of fossil fuels is tied to mineral resources, the competitiveness of clean energy is linked to equipment manufacturing, potentially leading to adjustments in the global industrial, trade and geopolitical landscape (Allan *et al*, 2021).

As the energy industry shifts from extraction to manufacturing, the industrial chain may undergo changes, allowing more countries to participate in the international division of labour, and potentially leading to lower energy prices because of increased supply. The production of clean-energy equipment involves various raw materials, such as iron, copper, lithium, cobalt and nickel, which are widely distributed and difficult to monopolise. Moreover, clean-energy equipment manufacturing typically occurs in factories, with location choices less constrained by geographical factors compared to the extraction industry. Clean-energy equipment can be transported on standard cargo ships, unlike fossil fuels, which require specialised transportation equipment. This allows more countries to engage in the supply of raw materials, component production and transportation of clean-energy equipment, enhancing international division of labour. As more competitors enter the clean-energy industry, the pricing power of traditional fossil-fuel monopolists may diminish, leading to a steady decline in global energy prices. This price advantage could make clean energy the preferred choice for global energy consumption.

However, the increased competitiveness in clean energy may disrupt vested interests, potentially leading to trade protectionism and hence market fragmentation. As clean energy increases the global energy supply, countries exporting lower-cost clean-energy equipment may capture larger international markets, impacting other nations' energy industries. To protect their clean-energy sectors and secure favourable positions in the global industrial chain, countries may implement trade protection measures, such as punitive tariffs or local procurement requirements. These measures could reduce trade volumes in the clean-energy sector, prompting countries to boost local manufacturing capacity for clean-energy equipment. This may inhibit the realisation of economies of scale in the global clean-energy industry. To limit trade protectionism, global trade governance rules may need to be revised. For example, the World Trade Organisation's subsidy and countervailing measures could emphasise the positive externalities of green products, clearly defining the scope of industrial subsidies and helping reduce trade disputes (Asmelash, 2023).

Moreover, the enhanced competitiveness in clean-energy equipment manufacturing may boost the scale advantages of large countries, enabling them to achieve faster economic development and green transitions (Kuik *et al*, 2019). Large countries, with relatively complete industrial systems, can achieve self-sufficiency in raw materials and independently produce clean-energy equipment, avoiding competitive disadvantages from resource monopolisation by other countries. Additionally, industrial clusters in large countries can generate positive externalities, with raw material suppliers and clean-energy equipment manufacturers operating in proximity, reducing transaction costs and accelerating knowledge dissemination. This enhances the efficiency of the clean-energy industry in large countries. Furthermore, larger markets in these countries allow for better spreading of fixed costs in R&D and infrastructure, reducing average costs and providing competitive advantages over other nations.

9.8 Economies of scale: the cornerstone of China's contribution to the global green transition

China leads the world in new energy production capacity and market share. In 2022, China's photovoltaic (PV) module production capacity comprised approximately 80 percent of the global total and new energy passenger-vehicle sales accounted for nearly 60 percent of worldwide sales.

As previously noted, the success of China's new energy vehicle industry over the past decade is not primarily due to supportive industrial policies or government subsidies. The country's vast markets and comprehensive manufacturing system have played crucial roles. With the given technology, China could manufacture almost everything more cheaply than elsewhere. This is not because of low labour costs – China's labour costs are already higher than those in many developing countries – but because China's clean-energy manufacturing industries and infrastructure are in better position to exploit economies of scale.

To fully capitalise on its scale advantages, China must address the adverse effects related to land use and the energy consumption associated with digitalisation. In terms of land use, similar to the early stages of property development when long-term negative impacts were often underestimated, the clean-energy sector may currently be overlooking potential negative consequences. Over time, the expansion of the clean-energy industry may compete with agricultural land for space. Regarding digitalisation, the benefits of economies of scale in new energy manufacturing could be undermined by the rapid increase in power consumption by data centres, which is growing faster than the renewable energy supply globally. To mitigate these issues, careful planning and the implementation of institutional measures are essential.

China's competitive edge in clean energy presents an opportunity to become a main player in the global green transition. By leveraging economies of scale, China can amplify the positive externalities of its clean-energy sector, offering lower-cost clean energy solutions worldwide and fostering global economic development and the green transition. However, this competitiveness may prompt some countries to implement trade protection measures against China's green products. To counteract this, China must adopt policies to promote technology innovation in the clean-energy industry, while strengthening regional and international trade ties to foster a global trade system that is friendly to the green transition.

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10 Charting a green-energy transformation in Africa

Rim Berahab and Karim El Aynaoui[68]

10.1 Introduction

The demand for energy in Africa is growing rapidly, driven by population growth, urbanisation and industrialisation. Nevertheless, over 600 million Africans still lack access to electricity, which represents a significant energy gap for the continent. At the same time, Africa is endowed with vast renewable-energy potential, including abundant solar and wind resources, along with emerging technologies such as green hydrogen. It is crucial to unlock this potential to meet Africa's energy needs and to foster sustainable economic development. Africa is well-placed to capitalise on the global drive for clean energy technologies and supply chain development, as renewable energy offers the dual benefits of expanding energy access and promoting green industrialisation across the continent.

Nevertheless, achieving this transformation will be complex, involving a range of challenges in relation to governance, policy, financing, costs, domestic markets and competitiveness. Effective governance is vital to guarantee a coordinated and inclusive transition. However, many African countries are confronted with political instability, regulatory uncertainties and fragmented institutions, which

68 The authors are grateful to Youssef El Jai and Sabrine Emran for their contributions in the preparation of this chapter.

make the implementation of ambitious renewable energy policies more challenging. Robust governance frameworks are thus essential to secure the investment required to scale-up renewable energy projects across the continent. It is equally important to consider the policy environment, which should strike a balance between the urgent need for energy access and specific challenges faced by Africa and the sustainability and climate goals.

Financing the energy transition represents another significant challenge. While there has been a growth in renewable energy investment globally, Africa has yet to attract comparable levels of funding because of limited access to international capital markets, perceived investment risks and inadequate financial infrastructure. It is vital that innovative financing mechanisms, such as blended finance and green bonds, are introduced to reduce the risk profile of investments and make renewable energy projects more attractive to investors.

The high costs involved add another layer of complexity to the transition process. Despite the fact that renewable technologies have become more affordable on a global scale, the high upfront capital requirements, inadequate grid infrastructure and small domestic markets in Africa make renewable energy projects less financially viable without external support. Furthermore, domestic energy markets in Africa are frequently fragmented and underdeveloped, characterised by low demand, underinvestment and energy losses. Reforming these markets and facilitating regional integration through cross-border energy trade and power pools is crucial for building economies of scale and enhancing competitiveness. Furthermore, Africa is facing intense global competition for renewable-energy investment, with Asia, Europe and the Americas already attracting significant capital and developing more mature renewable industries.

To achieve Africa's green-energy transformation, decisive and collaborative action is required at all levels. Governments, private-sector entities and international partners must collaborate to boost investment, reinforce regulatory structures and cultivate a conducive environment for transformative change. Morocco's experience demonstrates the success of calculated risks in the green-energy sector, as evidenced by its strategic investments in renewable energy, which have enabled the country to achieve numerous milestones in the development of this sector.

However, for Africa to succeed as a whole, African countries must create favourable market conditions and invest in local research, innovation and manufacturing capabilities. African countries remain significantly reliant on imported technologies, particularly in sectors such as solar and wind power. This underscores the necessity for increased investment in research and development (R&D) within the region. Innovation and R&D are essential for the development of a sustainable and competitive green-energy sector in Africa. Universities, research institutes and local industries must spearhead technological advances, develop local solutions and cultivate skilled workforces capable of supporting the continent's energy transition. By strengthening these pillars, Africa can reduce its dependence on imported technologies, create new economic opportunities and establish itself as a key player in the global clean-energy market.

This chapter identifies key lessons and challenges facing Africa as it transitions to green energy, and outlines strategies for ensuring a successful green-energy transformation.

10.2 Lessons from Morocco's energy transition experience

10.2.1 A successful energy transition requires a proactive public sector, a clearly defined institutional framework and effective regulation

Africa's energy landscape is changing rapidly, with renewable energy becoming increasingly important. The share of renewable energy in electricity generation in Africa increased from 18 percent in 2000 to 24 percent in 2022[69], with an average annual growth rate of 5 percent

69 Latest data available at time of writing.

over the same period[70]. However, the success of such a transformation depends heavily on the implementation of national strategies that emphasise the role of the state, the creation of solid institutional frameworks capable of implementing the strategy and the establishment of effective regulation that ensures transparency, competition and balance in the energy market. These frameworks are essential for coordinating the various stakeholders in the energy sector and ensuring that policy implementation is strategically sequenced to balance development objectives and environmental sustainability, while addressing the critical need for energy security. This is particularly important for Africa, where access to reliable energy is still limited.

What has happened in Morocco illustrates the important role of the state in implementing an energy-transition strategy. Faced with an energy demand that is expected to triple by 2030 and a heavy reliance on imported fossil fuels – more than 90 percent of its energy is currently imported – Morocco launched a National Energy Strategy in 2009. The strategy aims to diversify the energy mix by harnessing the country's vast renewable resources, particularly solar and wind power, to enhance energy security and support sustainable economic growth. By 2023 Morocco had made significant progress, with nearly 41 percent of its installed capacity[71] coming from renewable sources, positioning the country to meet its target of 52 percent by 2030 (ONEE, 2024).

In terms of electricity generation[72], up to 7,483 gigawatt hours were

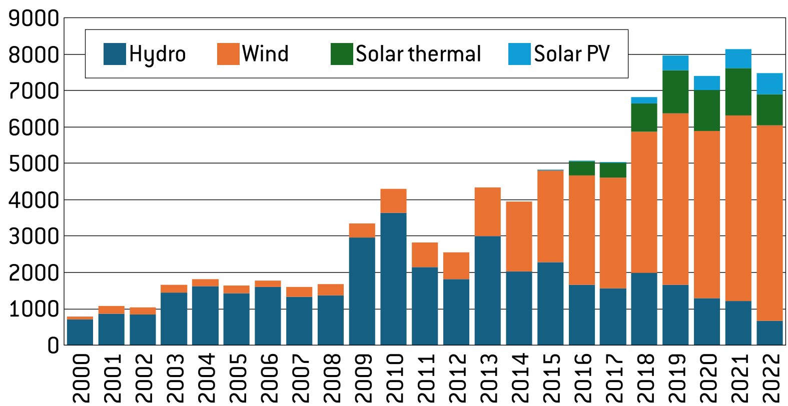
70 See International Energy Agency, 'Where does Africa get its energy?' undated, https://admin.iea.org/regions/africa/energy-mix.

71 Installed capacity refers to the maximum amount of electricity that a power plant or energy system is capable of producing under ideal conditions. This is typically measured in megawatts (MW) or gigawatts (GW). It represents the total potential output of all energy sources (renewable or non-renewable) connected to a grid.

72 It refers to the actual amount of electricity produced over a specific period, typically measured in megawatt-hours (MWh) or gigawatt-hours (GWh). While installed capacity represents a fixed measure of potential, electricity generation is subject to fluctuations depending on factors such as fuel availability, maintenance and operational efficiency.

generated from renewable energy, representing about 18 percent of total national electricity generation in 2022[73], compared to 782 GWh in 2000, translating to annual average growth of 11 percent during the 2000-2022 period (Figure 1)[74].

Figure 1: Share of renewable energy in total electricity generation, Morocco, GWh



Source: International Energy Agency.

The speedy progress of Morocco's energy transition can largely be attributed to the establishment of a favourable institutional framework that has enabled several achievements. The Solar Plan, issued in 2009 as part of the broader national energy strategy, set specific targets and pathways for increasing the share of solar energy in the country's electricity mix. Similar plans have been implemented to develop and guide the expansion of large-scale wind power projects. The creation of the Moroccan Agency for Sustainable Energy (MASEN), which works alongside the National Office for Electricity and Drinking Water

73 Latest data available at time of writing.

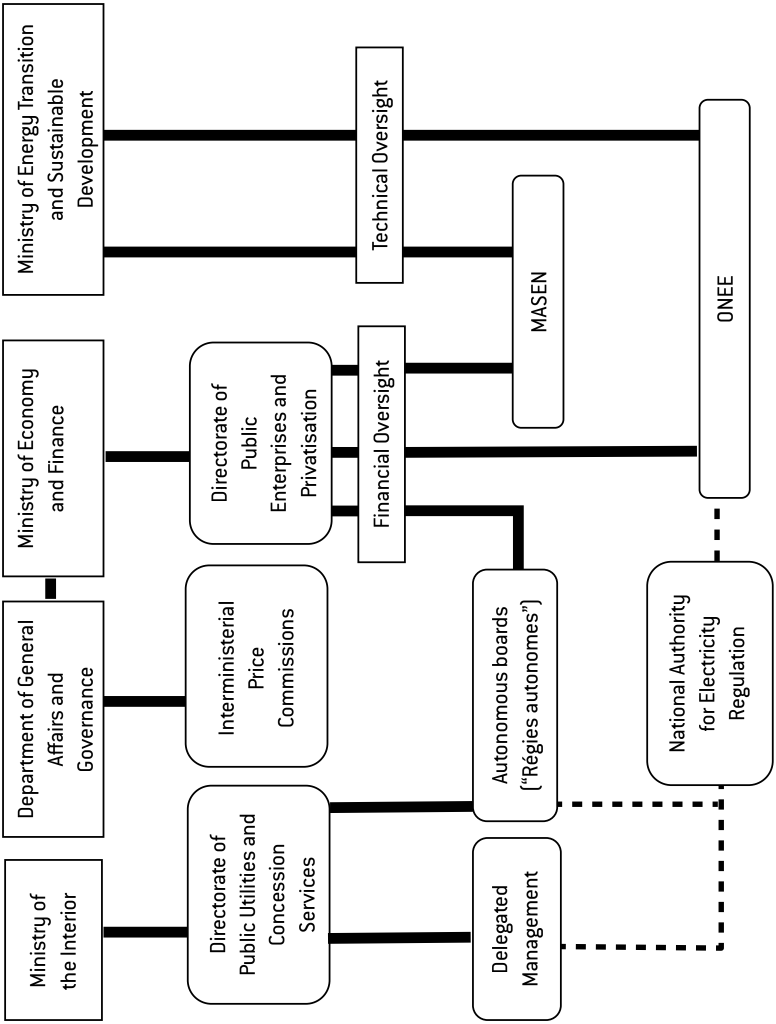
74 See International Energy Agency, 'Morocco', undated, https://www.iea.org/countries/morocco/renewables#.

(ONEE), has provided essential institutional oversight for these initiatives in terms of coordinating and implementing renewable-energy projects in line with national energy goals. Morocco has also introduced several laws and regulations aimed at opening up the energy market and encouraging private-sector participation. Moroccan Law 13-09 is a prime example. This law, which allows private companies to produce and sell electricity from renewable sources, was designed to create a more competitive energy market.

However, despite these achievements, Morocco's institutional framework has reached its limits. It faces significant challenges that underscore the need for continuous improvement. Competition between key institutions, such as MASEN, ONEE and the Ministry of Energy Transition and Sustainable Development, has sometimes led to overlapping responsibilities and fragmented efforts.

The organisation (Figure 2) and structure of the Moroccan electricity market illustrates these challenges. The market is characterised by a hybrid model, with a regulated segment dominated by ONEE and municipal distributors, and a smaller open market in which private generators can sell electricity directly to industrial consumers. However, this open market remains small, accounting for only about 7 percent of the electricity traded annually in Morocco (Amegroud, 2022). The dominance of public entities such as ONEE, combined with the need for significant investment in infrastructure and modernisation, suggests that Morocco's institutional framework needs to evolve to support a more decentralised and competitive energy market in which the private sector would play a greater role.

Figure 2: Organisation of the electricity sector in Morocco



Source: Amergroud (2022).

MASEN has also faced challenges related to financing and investor confidence. While the agency succeeded in securing financing for large projects through power-purchase agreements (PPAs) with private investors, the use of government guarantees has revealed some weaknesses. The hybrid nature of the energy market, with a small open market coexisting with a predominantly regulated market controlled by ONEE, which remains the sole purchaser of electricity generated by MASEN-led projects, has limited the agency's flexibility in promoting market-led expansion of renewable energy.

In terms of regulation, Morocco has experienced a number of delays, despite some notable progress. Law 13-09, enacted in 2010 and amended in 2015, while paving the way for private companies to enter the renewable energy market, has several limitations that reduce its effectiveness. Access to the national grid for private producers remains complex and costly, slowing the development of new projects. In addition, the law does not provide sufficient financial incentives, such as subsidies or feed-in tariffs, to stimulate investment, which discourages small companies and local investors in particular. In fact, the law focuses primarily on large industrial projects, neglecting small producers and distributed generation, which limits the diversity of players in the market. For example, only projects connected to the high and extra-high voltage (HV and EHV) transmission grid have been approved, leaving out small producers that could contribute to a more decentralised grid (Amegroud, 2022).

The regulatory framework also lacks clarity, particularly with regard to pricing and the management of surplus electricity. The administrative slowness and bureaucracy associated with project approvals significantly hampers their implementation. For example, although the law theoretically allows electricity transactions between private generators and end-users, as well as third-party access to the transmission grid managed by ONEE, few permits have been issued because of technical and regulatory constraints and the limited size of the target market.

In addition, the technical challenges associated with integrating large-scale renewable energy projects into Morocco's ageing grid infrastructure have posed further obstacles. The limited capacity of the grid to handle intermittent renewable energy sources has required significant upgrades, complicating Morocco's efforts to meet its ambitious targets. These infrastructure constraints, combined with regulatory uncertainties, have at times slowed the pace at which Morocco has been able to increase its renewable-energy production.

10.2.2 Industrial integration is a key driver for the competitiveness of renewable-energy technologies

Improving the competitiveness of renewable-energy technologies goes beyond large-scale deployment. It requires a coherent industrial policy that promotes local content development, industrial growth and the establishment of a robust supply chain. Industrial integration, which includes domestic production of materials, technologies and components, is critical to maximising the economic benefits, including job creation, technology development and increased competitiveness in the global market.

Morocco's energy transition has been highly capital-intensive. Since the launch of its national energy strategy in 2009, the country has invested approximately 60 billion dirhams (about €5.7 billion, 2025 prices) in renewable-energy projects, resulting in the development of 4.6 gigawatts of renewable-energy capacity. An additional 23 billion dirhams has been allocated for the period 2023 to 2027 to increase renewable energy integration and secure the country's electricity supply[75]. However, while some industrial integration has been achieved, industrial growth has not materialised to the expected extent, despite significant financial investments.

75 *TELQUEL*, 'Selon Leila Benali, l'investissement en énergies renouvelables sera quadruplé à l'horizon 2027', 24 January 2024, https://telquel.ma/instant-t/2024/01/24/selon-leila-benali-linvestissement-en-energies-renouvelables-sera-quadruple-a-lhorizon-2027_1852935/.

In the solar-energy sector, local industrial integration rates range from 25 percent to 45 percent, depending on the type of project. This integration includes locally sourced materials for construction, but key components such as turbines, photovoltaic (PV) panels, inverters and tracking systems are still imported due to their significant share of the total investment cost (Table 1). The reliance on imported components limits the degree of industrial integration and increases overall project costs. The inflationary context currently prevailing in the world and in Morocco tends to push up the cost of clean energy, resulting from the consequences of the pandemic, the rise in transport prices for components imported from China and certain difficulties experienced in Europe.

Table 1: Moroccan imports of components intrinsic to PV panels

Component (Moroccan customs nomenclature)	2017	2021	2022	2023
Encapsulating films (3919903061)	7 512	7 568	61 843	6 610
Solar glass (7007192000)	72 944	11 185	522 473	15 270
Aluminium frames for PV panels (7616999040)	13 118	15 063	13 998	5 157
PV cells (8541401000)	20 260 017	16 384 733	70 517	100
Junction boxes (8536909093)	4 975	7 725	6 385	1 210

Source: *Office des changes*.

In comparison, the wind-energy sector has a better integration rate of around 35 percent due to local production of turbine blades and local tower assembly (CRI BOA, 2023). The Siemens Gamesa plant in Tangier has been a key contributor to this achievement. Opened in 2017 with an investment of €100 million, it has produced turbine blades and created around 600 direct jobs, supporting Morocco's vision of becoming a hub for renewable energy manufacturing[76]. However, the plant's closure in 2022, as a consequence of global market pressures and financial losses, marked a significant setback for Morocco's renewable energy industrial capacity. This closure highlighted the fragility of local industrial operations without strong regulatory and financial support.

In addition, Moroccan companies, particularly in the photovoltaic industry, face fierce competition from Chinese firms that dominate the global solar market. The lack of a robust regulatory framework and local content requirements has further discouraged domestic manufacturing and limited technology transfer. This reliance on imported technology not only drives up project costs, but also reduces opportunities for local job creation. It also hinders the development of a strong local supply chain, a key factor in the long-term sustainability of the renewable-energy sector.

Financial barriers also play a critical role in hindering industrial integration. While the government has established financial mechanisms such as the Energy Development Fund and the Energy Investment Company to support local companies, these programmes are not sufficiently tailored to the specific needs of domestic companies. Local companies struggle to secure the necessary capital to remain competitive and the regulatory framework has not mitigated the risks associated with investing in local content projects. As a result, opportunities to attract both domestic and international investment in local manufacturing remain limited, hindering the growth of a robust renewable energy sector.

To address these challenges, Morocco has implemented initiatives such as the Industrial Acceleration Plan (PAI) and the National Pact for Industrial Emergence, which aim to strengthen local industrial

76 *Médias24,* 'Siemens Gamesa ferme son usine tangéroise de pales d'éolienne', 15 September 2022, https://medias24.com/2022/09/15/siemens-gamesa-ferme-son-usine-tangeroise-de-pales-deolienne/.

integration by promoting domestic production and developing local expertise. By linking universities, research institutes, start-ups and national companies to renewable-energy projects, these programmes aim to strengthen technology ownership and develop local know-how, creating a more sustainable and competitive renewable energy sector (CESE, 2020).

In recent years, Morocco has also set its sights on developing a green-hydrogen industry, recognising its potential to decarbonise industries such as transportation, chemicals and fertilisers, and to export surplus energy. The country's abundant solar and wind resources, combined with its strategic proximity to European markets, provide a competitive advantage in the production of green hydrogen, particularly for export. A notable example is Morocco's cooperation with Germany, which led to a partnership to build a green-hydrogen production plant in 2020. This project is expected to produce clean hydrogen and green ammonia for both domestic use and export, helping both countries meet their climate goals[77].

However, there are significant challenges to scaling up green-hydrogen production. High infrastructure costs and the need for technological advances to make electrolysis more cost-effective and efficient are major hurdles. Water availability is also a pressing issue. Green-hydrogen production requires significant amounts of water – about nine litres per kilogramme of hydrogen. On an industrial scale, this would put a significant strain on Morocco's water resources. To mitigate this, the country is exploring solutions including desalination, water recycling and integrated water management to ensure that green-hydrogen production does not compromise water security. Hence, the crucial role of industrial policy to oversee these initiatives.

77 See GIZ, 'German-Moroccan Energy Partnership', undated, https://www.giz.de/en/worldwide/152595.html.

10.2.3 Innovation and research and development are the missing link to foster green growth

Innovation and R&D are essential to building a sustainable and competitive green-energy sector. While African countries, including Morocco, have made significant investments in renewable-energy infrastructure, there has been insufficient focus on fostering local innovation and building capacity in technology development. This gap in domestic innovation has led to a heavy reliance on imported technologies, especially in critical sectors such as solar and wind energy. To overcome this challenge, universities and research institutions must play a key role in driving technological advances, supporting local industries and developing a skilled workforce capable of contributing to the green energy sector.

Morocco's Mohammed VI Polytechnic University (UM6P) and the Research Institute for Solar Energy and New Energies (IRESEN) have begun to fill this gap through various initiatives. UM6P's Green Energy Park, for example, serves as a platform for the development and testing of solar technologies, providing valuable data and insights for the industry. Similarly, IRESEN's NOOR test platform allows solar and wind technologies to be tested in desert conditions, advancing the region's understanding of how to optimise renewable-energy solutions in harsh environments. Despite these positive steps, Morocco's overall R&D spending remains low at just 0.7 percent of GDP – well below the global average of 2.3 percent. This low investment in R&D undermines Morocco's ability to foster technological innovation and grow its renewable-energy sector on its own.

One area in which increased innovation could have a transformative impact is in the development of green hydrogen. Morocco's strategic location, abundant renewable-energy resources and proximity to Europe give it a competitive advantage in this emerging market. However, without significant advances in R&D – particularly in the areas of electrolysis and energy storage – Morocco's ambitions could be hampered and the country could remain dependent on foreign expertise and technology to achieve its green-hydrogen goals.

Several pilot projects are already underway as part of Morocco's national green-hydrogen roadmap. These projects act as proof of concept and demonstrate the potential of integrating renewable energy and hydrogen technologies within the country's ecosystem of research platforms, public agencies and energy companies. Significant examples include (Berahab and Zarkik, 2023):

- The Power-to-X Project: This is Morocco's first large-scale green hydrogen industrial project, developed in collaboration with MASEN (Moroccan Agency for Sustainable Energy) and the German government. Scheduled for commissioning in 2025, the project will feature a 100 MW renewable energy plant producing green hydrogen through electrolysis, showcasing the integration of renewable energy into industrial applications.
- Hevo Ammonia Morocco Project: This project aims to produce green ammonia and hydrogen in collaboration with the Portuguese company Fusion Fuel Green and the engineering firm Consolidated Contractors Company (CCC). Initially launched in 2022 after a feasibility study, the project underscores Morocco's efforts to develop green ammonia as a key derivative of green hydrogen.
- Small-scale Green Ammonia Production: In partnership with the OCP Group (Morocco's state-owned phosphate and fertiliser producer), IRESEN, UM6P and the Fraunhofer Institutes in Germany, this project will produce four tonnes of green ammonia per day, powered by a 4 MW electrolysis unit. The collaboration highlights Morocco's drive to integrate green hydrogen into its industrial sectors, particularly in areas including agriculture and fertiliser production.

These initiatives are part of Morocco's broader strategy to capitalise on its renewable-energy ecosystem by leveraging research, public-private partnerships and international cooperation to develop a green-hydrogen value chain. Morocco has signed several agreements with European countries to jointly develop R&D projects and promote the production and export of green hydrogen. However, these same European countries are also exploring partnerships with other Mediterranean countries, indicating that Morocco faces competition to become a key player in the global green-hydrogen market. To secure its position, Morocco will need to accelerate its R&D efforts, ensure that local industries are integrated into the value chain and provide clear regulatory support to attract investment and encourage innovation.

10.3 Case studies in sub-Saharan Africa

10.3.1 The Democratic Republic of Congo: a resource-rich nation struggling to harness its energy potential

The Democratic Republic of Congo (DRC) is endowed with vast renewable and non-renewable energy resources, yet it faces extreme energy poverty. The country relies heavily on traditional biomass, which constitutes 94 percent of its total energy supply and 91 percent of total final consumption[78]. This reliance on biomass, mainly used in the residential sector for cooking and heating, uses outdated methods and leads to significant energy wastage and severe environmental degradation, particularly through deforestation.

However, the DRC has enormous hydroelectric potential. The Inga Dams, a set of hydroelectric plants located on the Congo River, have a potential capacity of over 40,000 MW, equivalent to 16 percent of Africa's total installed capacity in 2023. However, their current operational capacity is just 1,775 MW, less than 1 percent of Africa's total installed capacity in 2023 – far below what is necessary to meet domestic demand, let alone regional energy needs (Scherer, 2021;

78 See International Energy Agency, 'Where does Democratic Republic of the Congo get its energy?' undated, https://www.iea.org/countries/democratic-republic-of-the-congo/energy-mix.

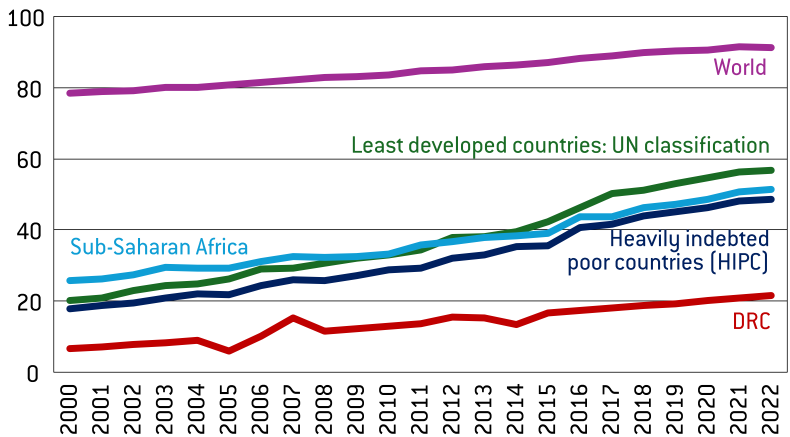
Bloomberg, 2024). These facilities, including the Inga I (351 MW, operational since 1972) and Inga II (1,424 MW, operational since 1982), suffer from poor maintenance, deferred upgrades and limited capacity utilisation. As a result, they operate at only 40 percent of their installed capacity, exacerbating the energy-access crisis in the country (Scherer, 2021).

The ambitious Inga III project, which is still in the design phase, aims to generate 4.8 GW of power. However, like its predecessors, Inga I and II, Inga III faces criticism for its financial risks, social displacement issues and environmental impacts. If completed, the Grand Inga complex could produce up to 45 GW of electricity, making it the largest hydroelectric power station in the country (Scherer, 2021). Yet, the project's failure to benefit local populations raises serious concerns, as previous hydro projects have primarily served industrial mining operations in Katanga and export markets, rather than improving access to electricity for the general population.

These challenges are compounded by the fragmented governance of the DRC's energy sector. Weak coordination among government bodies and an unpredictable regulatory environment continue to undermine progress. Corruption, particularly within state-owned enterprises such as Société Nationale d'Électricité (SNEL), exacerbates these issues. SNEL has a history of mismanaging infrastructure and energy projects, deterring investors who are wary of the lack of transparency and the associated risks. The reliance on public-private partnerships (PPP) for large-scale projects such as Inga III has also sparked concern. Inga I and II, funded through a mix of international loans and private investments, are frequently cited as failed mega-projects that did not bring the promised benefits to local communities. Given the DRC's troubled track record with governance and transparency, the Grand Inga project risks repeating the same mistakes unless substantial reforms are made (Scherer, 2021).

Furthermore, energy efficiency remains a critical issue in the DRC. The country suffers from energy losses during production and transmission due to outdated infrastructure and inefficient systems. This inefficiency severely hampers the DRC's ability to deliver power to its population. Overall, only 22 percent of the population has access to electricity, highlighting the stark disparity and the failure to harness the country's vast energy potential (Figure 3). In addition to the inefficiencies in the transmission and distribution system, infrastructure development is hampered by the country's vast and challenging geography. Poor roads, transportation systems and lack of financing make it difficult to install and maintain energy infrastructure, particularly in remote areas. The high development costs, combined with the population's low purchasing power, make large-scale electrification projects financially unfeasible without substantial external investment.

Figure 3: Access to electricity (% of population)



Source: World Bank, 'Access to electricity (% of population)', https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS. Note: latest available data, 2022.

Despite the overwhelming challenges, there have been some efforts to address the DRC's energy crisis. The government has set a target to increase electricity access to 32 percent by 2030, though achieving this will require significant reforms in governance, infrastructure investment and energy efficiency improvements. Additionally, the DRC has joined the Renewable Energy Transition Africa (RETA) platform, which is intended to promote renewable-energy development across the continent. Efforts to develop off-grid solutions, particularly in solar energy, are also gaining traction, though the sector lacks a comprehensive policy framework to support long-term growth. Solar energy has enormous potential in the DRC, given its geographical position, but remains largely unexplored and underdeveloped.

The DRC's energy challenges are compounded by its critical role in the global supply of minerals essential for the clean-energy transition. The country is the world's largest producer of cobalt, accounting for over 70 percent of global supply, and is a significant producer of copper, both of which are crucial for electric vehicles (EVs) and renewable-energy technologies. Emerging sectors such as lithium and rare earth elements also show significant potential. However, similar to the energy sector, the exploitation of these critical minerals is plagued by poor governance, corruption and lack of infrastructure. The extraction of cobalt, in particular, has been associated with severe environmental degradation, child labour and dangerous working conditions in artisanal mining. These issues tarnish the DRC's reputation as a reliable supplier of ethically sourced minerals, potentially jeopardising its future role in the global energy transition.

In response to these challenges, the DRC has acknowledged the imperative of capitalising on its abundant copper and cobalt resources to foster economic development. In collaboration with Zambia, the DRC has articulated a strategic vision aimed at producing batteries for EVs. This initiative took a formal shape in April 2022 when the DRC and Zambia executed a cooperation agreement to cultivate electric battery and clean-energy value chains, establishing a joint governance structure, named the DRC-Zambia Battery Council, alongside a technical committee tasked with the oversight and evaluation of the project's progression. Furthermore, the partnership anticipates the creation of cross-border Special Economic Zones in Kipushi, DRC and Ndola, Zambia, which will be dedicated to manufacturing battery precursors, batteries and electric vehicles[79].

This strategic initiative aims to forge an integrated value chain for electric vehicles and batteries, positioning the DRC and Zambia as pivotal contributors to, and not merely as passive observers of, global price dynamics. Nonetheless, the realisation of these ambitions hinges on addressing several pressing challenges. Critical among these is the enhancement of energy infrastructure, necessitating substantial investments in the modernisation and rehabilitation of roads, ports and railways. The infrastructure deficit in the DRC alone necessitates annual financing of approximately $4 billion (ICED, 2018).

10.3.2 Kenya: balancing sustainability, innovation and accessibility

Kenya has emerged as one of the leading nations in sub-Saharan Africa in renewable-energy development, with an ambitious energy transition strategy that sets the country on a sustainable and low-carbon development path. Driven by a combination of strong resource potential, forward-looking policies and international cooperation, Kenya's energy transition demonstrates a balanced approach to harnessing its natural resources while improving energy access and reducing carbon emissions.

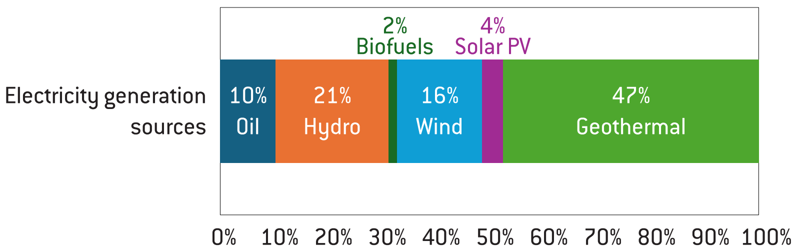
Kenya's energy transition is underpinned by an impressive renewable-energy portfolio, which accounts for about 90 percent of the country's electricity generation mix (Figure 4)[80]. Kenya is the largest producer of geothermal energy in Africa, with an installed capacity of approximately 900 MW (UNIDO, 2023). Geothermal plays a central role in Kenya's energy strategy, providing a reliable, baseload source

79 See United Nations Economic Commission for Africa announcement of 29 April 2022, 'Zambia and DRC Sign Cooperation Agreement to manufacture electric batteries,' https://www.uneca.org/stories/zambia-and-drc-sign-cooperation-agreement-to-manufacture-electric-batteries.

80 International Energy Agency, 'Where does Kenya get its energy?' undated, https://www.iea.org/countries/kenya/energy-mix.

of electricity. By 2021, geothermal accounted for approximately 41 percent of Kenya's total electricity generation. Geothermal development has helped Kenya reduce the intermittency associated with other renewable sources such as solar and wind. It also provides a stable power supply to support industrial and urban development, significantly reducing reliance on imported fossil fuels. Furthermore, Kenya is home to Africa's largest wind farm, the Lake Turkana Wind Power Project, which has been operational since 2018 with a capacity of 310 MW, contributing about 17 percent of the country's installed electricity capacity[81] (GWEC, 2023). In addition, hydropower contributes about 30 percent of Kenya's electricity, with major dams such as the Seven Forks on the Tana River forming a critical part of Kenya's renewable energy provision[82]. However, the country has become increasingly wary of hydropower because of its vulnerability to climate change and seasonal variability in rainfall.

Figure 4: Electricity generation, Kenya, 2023



Source: International Energy Agency.

81 European Investment Bank, 'Lake Turkana Wind Power,' 4 February 2013, https://www.eib.org/en/projects/all/20090484.

82 International Energy Agency, 'Where does Kenya get its energy?' undated, https://www.iea.org/countries/kenya/energy-mix.

Kenya's success in renewable-energy development can be attributed to the implementation of supportive policy frameworks and institutional reforms. The government's Least Cost Power Development Plan (LCPDP), updated every two years, outlines a long-term energy strategy that prioritises renewable energy. It focuses on reducing the country's dependence on imported fuels, while promoting energy access and affordability. Kenya's 2019 Energy Act is a comprehensive legal framework that further strengthens the regulatory environment for renewable energy investments. The Act provides for the licensing, regulation and oversight of energy generation, transmission and distribution, making the sector more attractive to private and foreign investors. In addition, the Geothermal Development Company (GDC), a state-owned enterprise, was established to de-risk geothermal exploration by carrying out preliminary surveys and drilling, which has been critical to expanding geothermal capacity. The GDC's role in geothermal energy has attracted significant international funding and partnerships, further cementing Kenya's leadership in the field.

Kenya's energy transition strategy is closely linked to its efforts to expand access to electricity across the country. By 2021, about 75 percent of Kenya's population had access to electricity, a significant improvement from just 23 percent in 2010[83]. However, there remains a significant urban-rural divide, with rural access still lagging behind. The government's Last Mile Connectivity Project, funded by the African Development Bank and the World Bank, aims to connect more than 1.5 million rural households by extending the national grid[84]. In parallel, Kenya is promoting off-grid solar energy solutions to power remote regions, with initiatives such as the Kenya Off-Grid Solar Access Project. Off-grid solar energy providers have adopted a

83 Mwangi Gakunga, 'Kenya Lauded for Achieving 75% Electricity Access Rate', COMESA, 9 June 2021, https://www.comesa.int/kenya-lauded-for-achieving-75-electricity-access-rate/.

84 African Development Bank, 'Kenya - Last Mile Connectivity Project', undated, https://mapafrica.afdb.org/en/projects/46002-P-KE-FA0-010.

business model based on a pay-as-you-go approach, to make solar panels affordable for the targeted population. Combined with solar home systems, this innovative financing approach has helped, to some extent, to address the challenge of reducing energy poverty (Berahab, 2020).

Financing has been a critical factor in Kenya's transition to renewable energy. The government has mobilised both private sector and international financing to support large-scale renewable energy projects. For example, the Lake Turkana Wind Power Project secured nearly $700 million in financing from a consortium of lenders, including the African Development Bank, the European Investment Bank and several private investors[85]. The Scaling Solar initiative of the World Bank Group's International Finance Corporation (IFC) is another example of international partnerships supporting Kenya's renewable-energy sector. This initiative is helping to reduce the cost of solar energy through a streamlined bidding process, creating bankable deals for investors. Kenya is working to replicate the success of wind and geothermal in the solar sector, with several projects in the pipeline.

While Kenya's energy transition strategy is commendable, it faces several challenges that must be addressed to ensure sustainable progress. Although geothermal and wind power are relatively stable, hydropower in Kenya, which remains an important part of the energy mix, is vulnerable to changing rainfall patterns. Droughts and shifting weather patterns resulting from climate change have increasingly disrupted hydropower generation, leading to periodic power shortages and the need for costly back-up power from fossil fuels.

Extending the national grid to underserved regions remains a challenge, particularly in remote, sparsely populated areas where

85 African Development Bank, 'Lake Turkana Wind Power Project: The largest wind farm project in Africa', 17 September 2015, https://www.afdb.org/en/projects-and-operations/selected-projects/lake-turkana-wind-power-project-the-largest-wind-farm-project-in-africa-143.

infrastructure development is costly. Despite significant improvements in energy access, power outages and grid instability continue to plague the country, affecting both urban and rural areas. Investment in grid modernisation is critical to fully integrate renewable-energy sources and ensure a consistent supply of electricity. In addition, while Kenya has been successful in securing financing for large-scale renewable-energy projects, there is still a financing gap for smaller, off-grid solutions that are critical to providing energy access in remote areas. The government needs to create more incentives and policies to attract investment in decentralised energy systems, particularly off-grid solar solutions.

10.4 Funding is the missing link

Overcoming energy challenges requires money. Unfortunately, in a world of polycrises and multiple priorities, relying on domestic funding/public funding will not be enough. African countries need a strong push from the private sector both domestically and externally. They also need the strong support of reformed multilateral financial institutions.

10.4.1 Limited fiscal space, low domestic resources mobilisation: modernising the policy framework to reduce credibility/commitment vs. discretion trade-off

The COVID-19 crisis caused many African countries to exacerbate policies of indebtedness, which started long before the pandemic. Emergency issuances on the international market have backfired with the return of inflation and the rise of interest rates as central banks worldwide rushed to hike their rates. Access to markets was closed for many of these countries and access to foreign funds was granted through multilateral agencies on concessional and non-concessional terms. With higher-for-longer interest rates, this situation is set to last, although easing off, given the ongoing change in monetary-policy orientation towards more accommodation (Canuto *et al*, 2023a).

10.4.2 Reforming the global financial architecture

With limited fiscal firepower, African countries are increasingly turning to multilateral development banks (MDBs) to source funding. At the same time, advanced economies, emerging economies and developing countries alike are calling for these institutions to address global issues such as climate change and pandemics more thoroughly. However, the current situation of the network of MDBs calls for a major overhaul to transform these institutions so they are fit for the twenty-first century.

The MDB financial model has become very rigid, preventing them from using their financial products for purposes beyond business-as-usual (ie extended guarantees, more blended finance, extensive use of hybrids). Moves to push for a more flexible balance sheet will result in additional funding thanks to a mix of capital-like operations (hybrids at the World Bank and the AfDB) and the launch of new products directed towards global public goods. However, ultimately, multilateral development banks will require general capital increases to be able to properly achieve their missions of serving all clients.

Furthermore, their operational models and governance introduce hurdles that lead to protracted financing processes. This leads to slow project development, even when developing countries have well-designed project pipelines. The risk culture within these institutions is characterised by excessive prudence, which leads to financing projects with mostly safe outcomes. Accepting a degree of uncertainty can provide more space to explore country-driven development strategies. It could also signal a much better evaluation of the risk for other investors, primarily the private sector. New institutions are not needed but they should be revolutionised through reform (Canuto *et al*, 2024; Belhaj, 2024).

10.4.3 MDBs might not be the only mechanism to deliver on climate (and global public good more generally)

The case for a green bank

Despite setbacks, MDBs continue to be a strong vehicle to drive development. The efforts that have been made throughout the decades since their establishment led to a steep decline in poverty rates until the pandemic. As a complement to these efforts, an institution or an entity could be created within the World Bank that would be fully dedicated to addressing climate change, with the appropriate tools. This green bank/institution should carry out two 'revolutions'. First, green funds should be rationalised. To bring an end to funding deviation, a single institution is needed to centralise all the money flowing towards climate funds, while being capable of making the best out of every single dollar injected into that circuit. The second revolution would be the introduction of an equally shared capital structure between public and private money. One of the limitations of the current model of the MDBs is the absence of the private sector at board level and the weak incentives for the private investors to join the pool of investors in large climate-mitigation and adaptation projects. Morocco's experience of renewable energy deployment has shown the importance of leveraging public and MDBs' money to attract investors and create ecosystems. Thus, the role of the Green Bank would also be to encourage the participation of the private sector simply by giving them a say in the decision-making process (Ghanem, 2023).

Green debt swaps

Debt is the second arm of the global financial architecture and has been associated with Africa and developing countries for good and, mostly, bad reasons. Many countries that were part of the Heavily Indebted Poor Countries (HIPC) Initiative and Multilateral Debt Relief Initiative (MDRI) were again at risk of severe risk distress after the COVID-19 pandemic. After drawing extensive funds, essentially from the international markets, to finance the sanitary and economic response, their fiscal situations deteriorated severely. The MDRI also translates several engagements taken with new creditors over the years, especially Chinese debt. In addition, higher rates from alternative creditors (non-Paris Club, private creditors) have led to shorter maturity periods and greater refinancing risks (Canuto *et al,* 2023b). While most African countries fared better than expected, with only a few hitting the debt wall and being forced to default (including Ghana and Zambia), this has happened at the price of painful budgetary adjustment, drawing funds away from education and health spending.

To resolve this situation, debt-resolution frameworks have to go beyond the G20 Common Framework and be designed to be equally attractive to official creditors and private creditors. The technicalities of the common framework and its inability to achieve this have been major impediments to an otherwise reasonable debt-resolution mechanism. Given the sense of urgency to act on climate, any reform of these procedures has to be green in nature. Pushing for debt-for-climate swaps, in case of pre-emptive restructuring, would be one way to do it. These mechanisms provide the appropriate incentives to all actors and allow countries to tailor restructurings that come with the double dividend of achieving climate key performance indicators with the active participation of private investors[86].

10.5 Recommendations

10.5.1 Strengthen the role of the public sector and implement adaptative regulation to guide Africa's energy transformation

Charting a green-energy transformation in Africa will require a strengthened, proactive and adaptable public sector that can guide the continent's energy transformation while addressing its unique

86 See Chakrabarty *et al* (2024) for a detailed proposal on the role of green bond markets in facilitating green swaps.

challenges. It is essential that Africa's energy systems strike a balance between the urgent need for sustainable solutions and the realities of uneven infrastructure development and access. To achieve this, African governments should assume a leading role in defining clear, long-term energy visions that are responsive to both national and regional needs. This includes the necessity for regulatory frameworks that evolve continuously in order to accommodate rapid technological advances and foster innovation.

It is also important for the public sector to focus on effectively coordinating the diverse stakeholders involved, from international investors to local communities, in order to streamline processes and avoid inefficiencies. By avoiding the creation of institutions with overlapping responsibilities, African nations can establish an environment conducive to private-sector involvement, which is essential for attracting the necessary investment for green-energy projects. Ultimately, flexible and forward-thinking regulation will ensure that Africa's energy transition remains competitive and inclusive, positioning the continent as a player in sustainable energy development.

10.5.2 Encourage PPPs through dedicated legal framework and define a role for state-owned enterprises

Morocco's model of leveraging public-private partnerships (PPPs) and state-owned enterprises (SOEs) in infrastructure development offers a blueprint for other African countries in terms of building sustainable, resilient infrastructure.

One of the strengths of Morocco's project planning is the legal framework on which it is based and a network of SOEs, which in conjunction with the private sector, are able to deliver large-scale infrastructure projects.

In the energy sector, the creation of NOOR is an example of conclusive cooperation between multilateral agencies, the public sector and the private sector (through ACWA Power). Legislation played a central role in mitigating risks and attracting investments for large infrastructure projects through legislative frameworks and PPPs, which would later be enshrined in law through a dedicated bill.

In addition, this happened in a context of sound macroeconomic management, notably speedy fiscal consolidation, in the aftermath of an external shock in 2012 that lead to a major deterioration of public finances. It constituted a major signal to investors to attract foreign direct investment. The creation of free zones next to major energy hubs was aimed at accelerating industrial integration, though it did not succeed as expected (section 11.2.2).

10.5.3 Stimulate green jobs by investing in renewable-energy industries, promoting local value content and fostering collaboration between the private sector and educational institutions

To fully benefit from the green transition, African countries need to invest in local manufacturing and processing, which would increase revenues and create jobs. For instance, Africa's rich reserves of minerals such as cobalt, lithium, manganese and graphite are critical to global decarbonisation and position Africa as a key player in the supply chain for renewable-energy technologies such as batteries, hydrogen production and transmission networks. If Africa, which accounts for 24 percent of global production, processed bauxite mines into aluminium using renewable energy before exporting it, it could save 335 million tonnes of CO2 emissions annually (equivalent to 1 percent of global emissions), create 280,000 jobs and generate an additional $37 billion in revenue for the continent (Osinbajo, 2024). However, to unlock the potential of green jobs beyond the mining sector, it is critical to develop a data-driven understanding of the green-jobs landscape in Africa. This includes identifying priority sectors, assessing skill requirements, mapping current labour market gaps and evaluating ongoing interventions. This type of analysis would better inform investment decisions and enable coordinated efforts to expand the green economy.

Another key factor in capitalising on green job opportunities is ensuring that Africa's young people are trained to meet industry needs. The African Development Bank (AfDB, 2023) estimates that more than 10 million young Africans enter the labour market each year, but only three million new jobs are created annually. To address this imbalance, collaboration between the private sector and educational institutions is critical. By aligning education and training programmes with industry needs, young people can be equipped with the skills needed for green jobs. In addition, reskilling workers from the fossil-fuel industry is essential to mitigate job losses and facilitate their transitions into new roles in renewable energy and other green sectors.

In Europe, for instance, initiatives to conceptualise hydrogen education and training started in the early 2000s, marked notably by the establishment in 2003 of the European Technology Platform for Hydrogen and Fuel Cells. The challenges of cultivating a hydrogen-ready workforce echo those observed in the broader renewable-energy sector. These issues include a misalignment between the educational offerings and the industry demands, and inadequacies in curriculum relevance on a global scale. Effective education and skilling are pivotal in fostering the development of a flexible and robust hydrogen economy (Beasy *et al*, 2023).

In Morocco, efforts to enhance training in green hydrogen include the development of executive training programmes, summer schools and hackathons focused on power-to-X technologies. Key contributors to these initiatives include the UM6P, the Mediterranean Green Electrons and Molecules Network (MEDGEM) and research and development entities including the Solar Energy and New Energies Research Institute (IRESEN) and the Moroccan Green H2 Cluster.

Gender equality also plays a critical role in ensuring inclusive growth in the green economy. Social norms and structural barriers continue to limit women's access to quality education and employment opportunities in green sectors. Efforts to challenge these norms and create equal opportunities for women and girls are essential. This could help tap into a broader talent pool, which is essential to drive the green transition across sectors.

10.5.4 Greening the public budget through synergies for energy transition

Budgets are pivotal for advancing energy transition and addressing climate change. Governments are positioned at the forefront of this challenge, requiring the adoption of green budgeting practices to fulfil their environmental pledges. Greening the budget involves integrating budgetary policy tools within a country's fiscal framework to support climate and environmental objectives (OECD, 2021). To transition to sustainable, low-carbon economies, it is imperative that national budgets prioritise green initiatives and avoid funding activities contrary to environmental goals. Current budgetary systems often overlook the alignment of expenditures with broader policy outcomes, typically allocating resources based on specific projects or programmes, rather than overarching national or policy objectives (Boutron, 2023).

Furthermore, siloed efforts within government ministries can hinder the efficacy of green policies. Collaborative approaches across ministries can phase out fossil-fuel subsidies and enhance support for renewable energy, clean technologies and sustainable practices. Building resilience in response to climate change and fostering low-carbon economic development require holistic, integrated strategies. Shifting from isolated to synergistic efforts is essential for merging sustainable development with climate adaptation and mitigation[87]. Pooling resources from various climate-funding sources amplifies the impact, facilitating more substantial, efficient, or ambitious outcomes than possible through individual funding streams. Integrating such initiatives within national strategic frameworks is crucial for the success of climate actions. Countries demonstrating consistent, sustainable and climate-resilient growth are better poised to harness climate finance in a synergistic manner (Wörlen *et al*, 2020).

Effective green budgeting can be achieved through several good practices: embedding it within a strategic national framework on

87 United Nations Development Programme, 'From silos to synergies,' 23 May 2017, https://www.adaptation-undp.org/silos-synergies.

climate and environmental action; utilising budgetary tools that support data-driven decision-making; establishing clear institutional roles and timelines; and ensuring transparency and accountability through robust reporting and independent oversight (OECD, 2021).

10.6 Conclusion

The global picture of green transformation on the African continent varies greatly, with a few countries taking the lead with ambitious transition plans. With increasing exposure to climate change, embarking on the green-energy transition is a necessity rather than a choice. In the face of this situation, African governments need to develop comprehensive strategies to attract investment in climate adaptation and climate mitigation.

In that respect, Morocco offers an example of a promising energy transition roadmap with a few ingredients that can be transposed to other African countries. Thanks to its governance model, based on proactive collaboration between the public sector, the private sector and multilateral agencies, Morocco has managed to advance on multiple renewable-energy sources and to increase its installed capacity. In the same fashion, the Kenyan example presents an ongoing success story in renewable-energy adoption, through geothermal and wind power. Still, despite these advances, both countries need to enhance their efforts to improve the industrial integration of renewable-energy projects. In particular, more has to be done to attract durable investments in local value chains. In Morocco, this goes hand-in-hand with the decentralisation of energy markets.

In parallel, African countries also need to integrate their innovation and R&D systems with their green development programmes. The limited dialogue between researchers and industry hinders further progress, especially as new technologies continuously emerge and require strong scientific involvement (eg green hydrogen). Foreign investment needs to contribute to significant technological transfers that consolidate local integration.

Finally, funding remains a fundamental challenge for Africa. Reform of the global financial architecture is pressing, given the fiscal constraints faced by African governments. The turn to accommodative monetary policy will relax this burden slightly. However, MDBs, principally the World Bank and the African Development Bank, must be equipped with appropriate financial tools to channel more funding to green development. Exploring innovative financing mechanisms, including climate swaps and the creation of an independent green bank, could help achieve efficiency and attract private finance at scale. It will require strong leadership and an open dialogue between creditor/donor countries in the North and recipient countries in the South.

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11 Global warming is worsened by the north-south divide

Jomo Kwame Sundaram[88]

11.1 Introduction

The wealthier large nations of the Global North have shaped the main policy responses to climate change. Without a substantial, urgent effort to curb global warming, these policies will not curb the processes soon enough to prevent irreversible catastrophe as average temperatures exceed the 1.5 degrees Celsius threshold above the pre-industrial mean. The worst consequences will be borne by the world's poorest countries, which have contributed little to greenhouse gas (GHG) emissions. Worse still, most developing countries lack the means to fund enough adaptation to climate change. Hence, those far less responsible bear the brunt of climate change and have the least means to cope with, let alone prevent, global warming.

This chapter analyses the injustices inherent in climate change and ostensible efforts to address them[89]. It explores the chasm between what is needed and actual actions taken. Finally, it explores how this can be addressed to mitigate and adapt to climate change more effectively.

88 The author is grateful to Luca Léry Moffat and Anna Fiore for their contributions to the work on this chapter.

89 Burden sharing in solutions to global warming is discussed in Jomo (2025).

11.2 Net-zero by 2050

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) committed to *"the stabilization* [sic] *of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic* [human-caused] *interference with the climate system"*[90]. Consequently, climate negotiations initially focused on stepping up mitigation efforts. Achieving 'net zero' initially only required cutting net GHG emissions and accumulation before the century's end in 2100, the original target year.

This was brought forward by the 2015 Paris Agreement which committed to *"undertake rapid* [emissions] *reductions … to achieve a balance between anthropogenic emissions by sources and removal by sinks of greenhouse gases in the second half of this century"* (UNFCCC, 2015a). The Intergovernmental Panel on Climate Change (IPCC) Special Report on keeping warming under 1.5°C (Rogelj *et al*, 2018) was used to advocate for this 'net-zero by 2050' target. Pledges to achieve this still-distant target have grown but inaction, underfinancing and broken promises have delayed urgently needed climate action in the near term.

Since the 2021 UNFCCC Conference of Parties (COP) in Glasgow, many governments have promised to achieve net-zero emissions by 2050, which is framed as achieving climate stabilisation. After reneging on various other Glasgow commitments, such as ending the burning of coal to generate energy, G7 Western leaders reiterated in April 2024[91] the net-zero by 2050 promise. After President Donald Trump's second inauguration, the United States then withdrew from the Paris Agreement for the second time.

90 The 1992 convention is available at https://unfccc.int/resource/docs/convkp/conveng.pdf.

91 See G7 Italia announcement of 24 April 2024 of Ministers' Meeting on Climate, Energy and Environment, https://www.g7italy.it/en/g7-ministers-meeting-on-climate-energy-and-environment/.

Net-zero by 2050[92] offers an attractively simple target for climate stabilisation. If fully met, net zero should stabilise the climate from 2050, but will certainly not check planetary warming in time. While the 2050 target year is significantly better than the earlier target year of 2100, it will not cut GHG emissions in time to avoid breaching the 1.5°C threshold in less than a decade. Worse, the agreement allows notable exemptions, such as for military purposes and air and marine transportation. In contrast to the excuses for inadequate concessional climate finance for developing countries, the US alone accounts for a trillion dollars, or two-fifths of total world military spending, of around $2.5 trillion yearly. Meanwhile, invoking the 'common but differentiated responsibilities' principle, some developing countries have bargained for more time. India, for example, has announced a 2070 deadline[93].

Government leaders have been more willing to make pledges far off into the future. After all, 2050 is almost three decades after the Glasgow COP in 2021. Net zero first appeared in the UNFCCC's 2014 Emissions Gap Report (UNEP, 2014) and at the UNFCCC COP (UNFCCC, 2015b). Removing GHGs will trap and absorb less heat in Earth's atmosphere. Hope in carbon sequestration continues despite no actual progress. There seems to be little recognition that most consequences of climate change, especially global warming, are largely irreversible. Yet, many carbon sequestration proponents still insist that 'carbon dioxide removal' and 'harmful emissions' technologies will be enough. Despite modest progress, there has been little feasible progress at scale in

92 Karl Ritter, 'A climate idea comes of age: Zero emissions,' *AP News*, 11 December 2014, https://apnews.com/general-news-abcef70cf9c24f0f8e10ccd6a4370557.

93 See statement delivered by India at the UN Security Council on behalf of Bolivia, China, Gabon, India, Iran, Iraq, Mali, Nicaragua, Panama and Syria of 7 June 2022, 'Cross-Regional Joint Statement on Global Net Zero,' https://pminewyork.gov.in/others?id=NDYzNA.

terms of carbon capture and storage[94]. There has been little significant growth in top-soil carbon sequestration, or large-scale tree planting and reforestation, with more controversial 'geoengineering' schemes much touted more recently. However, the IPCC Special Report (2022) warned that while some options might be technologically feasible, many have not proved viable at scale.

The International Energy Agency's revised Net Zero Roadmap for the 2023 Dubai COP led the UNFCCC to endorse "*transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science*" (IEA, 2023; UNFCCC, 2024). However, regardless of advocates' intentions, mitigation measures have been exaggerated and abused for greenwashing. The 2023 Emissions Gap Report noted that the gap between promise and practice has worsened (UNEP, 2023a).

The IPCC argued in 2014 that keeping global warming under 2°C would require *"near zero emissions of carbon dioxide and other long-lived greenhouse gases by the end of the century"* (IPCC 2014b). The European Union (EU) adopted a 2°C[95] threshold (Cointe *et al*, 2011) in 1996, insisting it should be for all.

However, some of the most vulnerable developing countries, mainly in the tropics, successfully insisted on 1.5°C. Following their sustained efforts, a later IPCC Special Report urged keeping average global temperatures under 1.5°C above pre-industrial levels.

94 Volker Sick, 'Not All Carbon-Capture Projects Pay off for the Climate – We Mapped the Pros and Cons of Each and Found Clear Winners and Losers', *The Conversation,* 12 January 2024, https://theconversation.com/not-all-carbon-capture-projects-pay-off-for-the-climate-we-mapped-the-pros-and-cons-of-each-and-found-clear-winners-and-losers-218425.

95 Carbon Brief Staff, 'Two Degrees: The History of Climate Change's Speed Limit', *Carbon Brief*, 8 December 2014, https://www.carbonbrief.org/two-degrees-the-history-of-climate-changes-speed-limit/.

Vulnerable poor nations rallied around "*1.5°C to stay alive*"[96] with many calling for a fossil fuel non-proliferation treaty to phase them out. Carbon budget projections have improved with better GHG emissions and atmospheric persistence monitoring techniques[97].

Governments pledged to meet the 2015 Paris Agreement goal of keeping global warming under 1.5°C. But former UN Climate Action and Finance Special Envoy Mark Carney expects the threshold to be breached in under a decade, over a decade and a half before 2050[98]. Over recent decades, the climate policy targets discourse has gone from emissions reduction to limiting temperature warming above pre-industrial levels.

11.3 Global North leadership

Primary responsibility lies with the Global North mainly due to its much greater contribution to GHG emissions, historically and *per capita*. Such emissions are also why the well-off in rich nations generally enjoy much higher living standards. The US has emitted a quarter of all carbon dioxide emissions since the 1750s, while Europe accounts for 31 percent. By contrast, Africa, South America and India contributed about 3 percent each, while China contributed 14.7 percent[99].

Taking 350 parts per million of carbon dioxide in the atmosphere as

96 Amy Martin, 'Meeting the 1.5°C Climate Goal Will Save Millions of People, and It's Still Feasible', *Scientific American*, 20 November 2023, https://www.scientificamerican.com/article/meeting-the-1-5-c-climate-goal-will-save-millions-of-people-and-its-still-feasible/.

97 Zeke Hausfather 'Why the IPCC 1.5C Report Expanded the Carbon Budget', *Carbon Brief*, 8 October 2018, https://www.carbonbrief.org/analysis-why-the-ipcc-1-5c-report-expanded-the-carbon-budget.

98 See 'Mark Carney: Investing in net-zero climate solutions creates value and rewards', United Nations interview, 2021, https://www.un.org/en/climatechange/mark-carney-investing-net-zero-climate-solutions-creates-value-and-rewards.

99 See Hannah Ritchie and Mark Roser, 'CO_2 emissions', *Our World in Data,* June 2020, https://ourworldindata.org/co2-emissions.

the upper limit to stabilise the climate and prevent disastrous climate change and apportioning this carbon budget as quotas to countries, rich nations used up their quotas around 1969, then overshot their 1.5°C quota in 1986, and their 2°C quota in 1995 (Fanning and Hickel, 2023). Even if the Global North achieves net zero, their cumulative emissions alone would still be thrice their 1.5°C 'fair share'.

The Global South is already suffering from climate change, which the Global North mainly causes. Many parts of the developing world are teetering on the brink of climate catastrophe, anxiously awaiting when devastating heatwaves, cyclones, floods or storms will strike. Meanwhile, many countries of the Global South are left too fiscally constrained to fund climate adaptation or repair losses and damages, let alone contribute, through decarbonisation, to mitigating further warming. Encouraged by the World Bank and others to borrow more on commercial terms with slogans such as 'from billions to trillions', many developing countries have faced severe debt crises, especially when Western central banks raised interest rates from 2022.

Many now spend as much on debt-service obligations as on education, health, social protection and climate adaptation combined (Development Finance International, 2023). In a rapidly worsening vicious cycle, large natural disasters require significantly more public spending and debt, while developing countries' interest payments outweigh climate investments (UNCTAD, 2024). This debt-climate nexus has already had a catastrophic effect on low-income countries (Mallucci, 2020; IMF, 2019b).

The North Atlantic Treaty Organization (NATO) responded to the Ukraine invasion, *inter alia*, by blocking Russian exports of oil and gas to Europe, raising the US share of European fossil-fuel imports. Faced with higher oil and gas prices, Europe has provided various energy price subsidies, which have lowered the effective carbon price, undermining carbon markets as a tool to mitigate planetary heating.

At the 26th UNFCCC Conference of Parties in Glasgow at the end of 2021, the UK host secured a commitment to abandon coal burning for energy. But the vow was soon abandoned, with coal mining in Europe revived to replace some of the Russian oil and gas imports.

11.4 Climate finance

Grossly unequal historical and current contributions to GHG emissions and the modest means of most of the Global South imply the Global North must take greater responsibility for climate change. The North must urgently contribute far more resources to enable developing countries to address the issue more effectively. This must involve urgently reducing carbon (dioxide) emissions to limit global warming to no more than 1.5°C above the pre-industrial level two centuries ago, as agreed to by the 195 parties to the 2015 Paris Agreement.

Despite commitments to climate finance, carbon markets, 'environment, social and governance' policies, the US Inflation Reduction Act and other legislation, emissions continue to rise. This is putting the world on track for a catastrophic 2.7°C warming over the pre-industrial average temperature level by the century's end (UNEP, 2023a). There are several reasons for this, some discussed later. The bottom line is that commitments from the Global North are wanting. However, many agreed policy targets distract from the urgency of reducing emissions to limit warming to no more than 1.5°C on average.

Providing far more climate finance on more generous terms has to be the main focus of the Global North's policies. Much more financing, on far more generous concessional rather than commercial terms, is also urgently needed for adaptation in the Global South. The finance required to address global warming is beyond the capacity of many developing countries (Chowdhury and Jomo, 2022). Countries of the Global North must recognise that the catastrophic consequences of the accumulation of their GHG emissions are already manifest worldwide with far worse effects in the Global South, where 3.6 billion people in low and lower-middle-income countries "*disproportionally bear the human costs of disasters due to extreme weather events and hazards*" (IPCC, 2022).

Mitigation remains important. Much more must be done to enable and accelerate the transition from fossil fuel combustion to renewable energy. Poorer countries should be enabled to leapfrog the fossil fuel stage that developed economies all went through. Such renewable energy investments to provide poor populations with affordable electricity may not be profitable enough to attract private investment. Developing countries cannot mobilise finance domestically, so international cooperation and commitment are necessary.

The Global North should deliver and significantly improve on what it promised in 2009, including the commitment to scale up support after 2020. Increasing total green investments by two percent of world income annually – to around $1.7 trillion, or a third of what governments currently spend on fossil fuel subsidies – could create over 170 million jobs, ensure cleaner industrialisation in the South and reduce GHG emissions by 2030[100]. While private finance tends to be more short-term in orientation, advanced countries should provide much more concessional climate finance (Bolton *et al,* 2024).

With the Global North's reluctance to provide much more generous climate finance, far more IMF Special Drawing Rights[101] (SDRs) must be issued to provide considerable urgent funding. SDRs are a grossly underutilised source of sorely needed climate and development finance. SDRs are international reserve assets that can be converted into currency by those holding them. The IMF allocated $400 billion in SDRs to rich countries in 2021 to help fund pandemic recovery, much of which was not used. In stark contrast, low-income and middle-income countries only received $250 billion since they are much smaller shareholders with considerably smaller quotas. At least 80 developing

100 See UNCTAD press release of 25 September 2019, 'UN calls for bold action to finance a global green new deal and meet the SDGs', https://unctad.org/press-material/un-calls-bold-action-finance-global-green-new-deal-and-meet-sdgs.

101 See IMF, 'Special Drawing Rights', https://www.imf.org/en/About/Factsheets/Sheets/2023/special-drawing-rights-sdr.

countries have used these allocations for various purposes[102]. Rich countries should direct their unutilised SDR allocations to climate funds or regional development banks for the Global South. These same countries can still do so now. Yet, there is no significant effort to enable this. This would provide massive amounts of much-needed funding at much lower interest rates than multilateral development banks currently offer to low-income countries (Ghosh, 2023)[103].

The Global North has failed to meet its modest and inadequate climate finance promises. At the 2009 UNFCCC COP in Copenhagen, rich countries pledged to provide $100 billion yearly in climate finance to developing nations until 2020. This was formalised in the 2009 Copenhagen Accord and reaffirmed by the Paris Agreement of 2015. The Green Climate Fund was formally established in December 2011 as the main channel through which climate finance is to be raised, disbursed and monitored. This framework was expected to deliver grants that mainly support developing countries. While modest compared to the finance needed to adequately address climate change – adaptation costs alone were estimated to average $215 billion annually until 2030 (UNEP, 2023b) – it was considered a promising start.

Unfortunately, rich countries have not kept their modest pledges. The promises were modest supposedly because they were made during the Great Recession in the aftermath of the 2008 global financial crisis and were to be significantly increased after 2020. There is a wide variety of estimates, all agreeing that total climate finance has fallen well short of needs. The OECD (2024) claimed the total amount

102 Andrés Arauz and Kevin Cashman, 'Eighty Countries Have Already Used Their Special Drawing Rights, but More of these Resources Are Needed,' Center for Economic and Policy Research, 26 January 2022, https://cepr.net/publications/eighty-countries-have-already-used-their-special-drawing-rights-but-more-of-these-resources-are-needed/.

103 Jayati Ghosh, 'SDRs Are the Great Untapped Source of Climate Finance,' *Project Syndicate*, 12 December 2023, https://www.project-syndicate.org/commentary/bolstering-climate-finance-through-special-drawing-rights-by-jayati-ghosh-2023-12.

of climate financing[104] by OECD members from 2013 to 2022 was $73.8 billion. In 2022, for the first time, this exceeded the $100 billion yearly originally promised in 2009.

However, even these OECD estimates are much disputed. Oxfam has argued the actual value of climate finance provided by rich nations to be as little as $28 billion and no more than $35 billion in 2022 – much less than claimed by the OECD report[105]. Oxfam attributed its much lower estimates to two factors. First, climate finance is dominated by loans, reported at face value rather than in terms of the estimated actual benefit to nations. Second, the climate impact of projects is often exaggerated. For example, some donors count development aid or official development assistance as climate finance, even when not primarily funding climate action, whether mitigation or adaptation.

Developing countries expected the $100 billion annual funding for climate finance, as agreed to at the 2009 UNFCCC COP, would mainly be in the form of public grants disbursed by the Green Climate Fund. Hence, providing climate finance as loans, especially commercial debt, is problematic. Much higher interest rates since 2022 have worsened recent sovereign debt crises and related contractionary fiscal austerity policies. Loans on less concessional terms continued to grow as a share of total public climate finance from 2016 to 2022 – 35 percent in lower-income countries and 85 percent in lower and middle-income countries (OECD, 2024). This has pushed poor countries deeper into debt, which has been exacerbated by more commercial lending. Private finance's actual role and impact are much disputed (Roberts *et al*, 2021), but it is unlikely to help countries most in need, let alone meet their policy priorities.

104 Provided and mobilised.

105 See Oxfam press release of 9 July 2024, 'Rich countries overstating "true value" of climate finance by up to $88 billion, says Oxfam', https://www.oxfam.org.uk/media/press-releases/rich-countries-overstating-true-value-of-climate-finance-by-up-to-88-billion-says-oxfam/.

Necessary adaptation – such as improving drainage, water catchment and infrastructure – is costly but necessary. Adaptation investments are rarely profitable and far less attractive to private investors, who favour mitigation investments more likely to generate higher returns. Unsurprisingly, only a yearly average of $1.5 billion of private finance was mobilised for adaptation from 2016 to 2021, primarily due to a single large project in Mozambique (OECD, 2023a). Furthermore, most private climate finance goes to middle-income countries where the profit potential is higher – less developed countries and fragile states received only 33 percent of private finance for adaptation, and small island developing states received 0.6 percent – equivalent to 0.1 cent per capita (OECD, 2023b).

Weak commitment to pledges made, even in multilaterally agreed arrangements, and inadequate climate finance, mainly in the form of private lending, have most hurt developing countries in need, especially the most vulnerable. Developing countries are supposed to be involved in decisions over disbursement, but they actually manage little among the many channels through which climate finance flows. Such conduct continues to deprive the Global South of agency in coping with, and otherwise rising to, the challenge of global warming.

11.5 Carbon and offset markets[106]

A basic underlying assumption in keeping the average temperature rise below 1.5°C above the pre-industrial level is that countries must meet net zero, ie not add to net worldwide GHG emissions. More than 130 countries have committed to achieving net zero by 2050. However, the still-distant net-zero by 2050 target has allowed the rich world to continue kicking the can down the road. Thus, they have avoided acting decisively and urgently to cut emissions sufficiently to avert exceeding the 1.5°C threshold, now expected in less than a decade. Achieving net-zero emissions typically relies on 'offsets' allowing

106 Market-based solutions to global warming are discussed in Jomo (2024).

countries and companies to avoid actually reducing GHG emissions.

Offset market advocates claim to reduce emissions or remove GHGs from the atmosphere through actions encouraged by incomes from selling 'carbon offsets'. In many cases, this means paying someone poor to cut emissions or forcing them to pay someone else to do so. Buying offsets allows big emitters to keep polluting, albeit at some cost. GHG emitting activities by wealthier individuals, companies, and nations can thus continue after "*transferring the burden of action and sacrifice to others*"[107] – typically to those in poorer nations – via the market.

At the most fundamental level, offset markets do not stop climate change since they do not actually reduce GHG emissions. They also fail to provide funds the Global South needs and distract from other more effective mechanisms such as 'polluter pays' fees[108]. After all, the logic of offsetting necessarily implies buyers get to keep emitting GHGs[109].

Thus, carbon offset markets have long overpromised but under-delivered. The Clean Development Mechanism, established under the Kyoto Protocol in 1997, allowed rich nations to invest in emission reduction projects in developing countries to meet their emissions targets. Cames *et al* (2016) found that 85 percent of Clean Development Mechanism offset projects would likely have happened without the offset programme. Only two percent of projects led to additional emissions reductions, exposing just how poorly offsetting substitutes

107 Robert Del Naja, 'We've toured the world for years. To help save the planet we'll have to change', *The Guardian,* 29 November 2019, https://www.theguardian.com/commentisfree/2019/nov/28/tour-world-massive-attack-band-climate.

108 See statement by 80 NGOs, 'Why carbon offsetting undermines climate targets – Joint NGO Statement', *Carbon Market Watch*, 2 July 2024, https://carbonmarketwatch.org/publications/why-carbon-offsetting-undermines-climate-targets-joint-ngo-statement/.

109 Doreen Stabinsky, Wim Carton, Kate Dooley, Jens Friis Lund and Kathy McAfee, 'Letter: Don't rely on carbon offsets as a climate change solution', *Financial Times,* 10 December 2020, https://www.ft.com/content/300213d3-7968-4219-a131-e433e6012b60.

for cutting fossil fuel use. Other established programmes – such as the United Nations' REDD programme[110] – have been bogged down in international negotiations and have failed to significantly reduce emissions. With the Paris Framework plugging some such loopholes, voluntary carbon offset markets continue to be touted as a solution[111]. Trading such non-verifiable offsets allows continued emissions with business almost as usual[112].

Despite modest climate benefits, the voluntary carbon offset market is expected to grow fifty-fold from 2020 to 2030[113]. This is likely to have particularly severe consequences in predominantly agricultural societies in the Global South since offset markets are intensifying competition for land. Land transfers for biofuels, green energy and conservation schemes have surged over the past decade, accounting for at least a fifth of land deals (IPES-Food, 2024). Governments worldwide increasingly include carbon removals involving land in national net-zero pledges, which adds up to almost 1.2 billion hectares of land – equivalent to current global cropland (Dooley *et al*, 2022). This is likely to have devastating impacts on biodiversity – 87 percent of large-scale land acquisitions are in areas of medium-to-high biodiversity (Lay *et al*, 2021).

More than half the land area pledged for carbon removal involves reforestation, which will likely put pressure on ecosystems, food security and indigenous peoples' rights (Dooley *et al*, 2022). The new land rush will continue to displace small-scale farmers, indigenous

110 See https://www.un-redd.org/.

111 Anders Porsborg-Smith, Jesper Nielsen, Bayo Owolabi and Carl Clayton, 'The Voluntary Carbon Market Is Thriving', *BCG Global,* 19 January 2023, https://www.bcg.com/publications/2023/why-the-voluntary-carbon-market-is-thriving.

112 Sabine Frank, 'Does carbon offsetting do more harm than good?', *Carbon Market Watch*, 6 July 2023, https://carbonmarketwatch.org/2023/07/06/does-carbon-offsetting-do-more-harm-than-good/.

113 Morgan Stanley, 'Where the Carbon Offset Market is Poised to Surge', 11 April 2023, https://www.morganstanley.com/ideas/carbon-offset-market-growth.

peoples, pastoralists and rural communities, eroding their access to land despite their general record of responsible stewardship. This will worsen the already dismal state of land ownership – globally, one percent of the world's largest farms control 70 percent of the land (Lowder *et al,* 2021). Hence, land inequality, driven by supposedly 'green' measures, will not only do little for climate but will worsen rural poverty, food insecurity and violence.

11.6 Conclusion

The Global North bears disproportionate responsibility for climate change due to historical and ongoing GHG emissions, while the Global South, mainly in the tropics, suffers most from its consequences. Promises and policies, such as the 2050 Net-Zero target, are clearly inadequate in addressing the urgent need for GHG emissions reductions, often delaying needed action, even if only inadvertently. Additionally, mechanisms such as carbon and offsets markets, as well as climate financing, have fallen far short, leaving the most vulnerable nations struggling to adapt. A more equitable multilateral approach is needed, where the North contributes much more to mitigation and adaptation efforts, acknowledging its role in causing the current climate crisis and providing most of the financial resources required for a sustainable and just transition.

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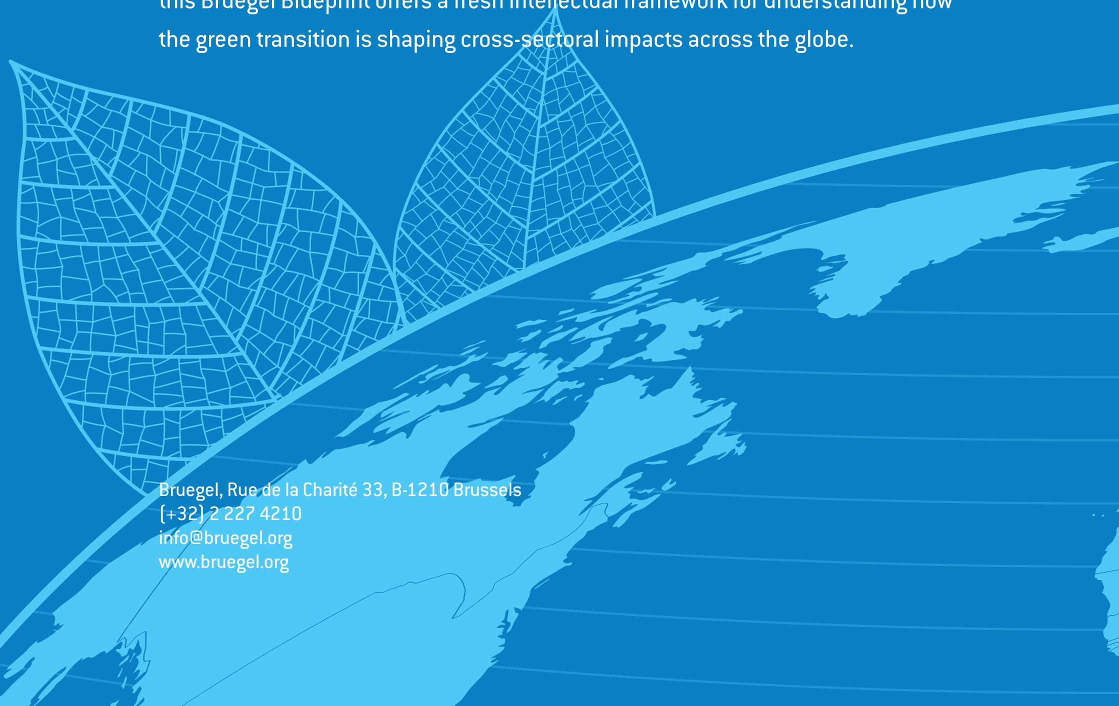
GREEN INTERSECTIONS

The global embedding of climate change in policy

Edited by Heather Grabbe and Simone Tagliapietra

Green objectives have reshaped public policy worldwide since the signing in 2015 of the Paris Agreement to limit global warming. From being one policy among many, the goal of tackling global warming is now embedded in public policies at every level, including energy, industrial, fiscal, trade, development and foreign policies. However, a clear outcome from this policy shift is yet to be seen, with emissions still rising and climate impacts intensifying. There is also backlash against greening in a charged geopolitical environment.

Nevertheless, the chapters in this volume, written by a range of experts worldwide, show that in many countries and policy areas, green objectives are still driving fundamental changes and many lessons have been learned. The goals of reducing emissions and enhancing economic and societal resilience to climate change will persist as climate impacts become more evident, and as the green transition produces successes at city, regional and national levels. In this context, this Bruegel Blueprint offers a fresh intellectual framework for understanding how the green transition is shaping cross-sectoral impacts across the globe.



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