THE ROAD TO

Net Zero

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Sarah Breeden examines risks to price and financial stability from climate change, and how they might grow

Jean Pisani-Ferry, Beatrice Weder di Mauro and Jeromin Zettelmeyer discuss Building coalitions for climate transition

Clean industrialisation for the EU is considered by Ben McWilliams, Simone Tagliapietra and Jeromin Zettelmeyer

SUSTAINABLE DEVELOPMENT

Foreword

Welcome to the Autumn edition of The Road to Net Zero, a *World Commerce Review* supplement. This publication has been prepared in response to readership demand for an overview of the steps being taken in the transition to a cleaner and greener sustainable world.

All aspects of climate action are examined, with the most respected authors providing the reader with the most comprehensive information available. Our brief is to provide all the data necessary for the readership to make their own informed decisions. All editorials are independent, and content is unaffected by advertising or other commercial considerations. Authors are not endorsing any commercial or other content within the publication. ■

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Building coalitions for climate transition

The planet's future depends increasingly on emerging and developing economies. Jean Pisani-Ferry, Beatrice Weder di Mauro and Jeromin Zettelmeyer argue that a four-pillar strategy could align key climate and economic goals into global trade

Executive summary

Global climate and biodiversity outcomes will largely be determined in emerging and developing economies (EMDEs). We propose a four-pillar strategy to support climate and nature preservation in line with the economic interests of both developing and advanced countries.

This would move beyond voluntary pledges to embed climate and nature objectives into the structures of trade, finance and industrial policy, creating a self-reinforcing system of cooperation and reducing the net costs of the green transition.

Under Pillar 1, a coalition of advanced and developing countries would link tiered carbon pricing with a common carbon border adjustment mechanism (CBAM). Pillar 2 would create a climate-finance coalition to decarbonise the power sectors of developing countries. Pillar 3 would involve partnerships to develop clean energy-intensive industrial production stages in developing economies with rich renewables endowments; these would feed into the supply chains of the European Union and other energy-importing advanced economies. Pillar 4 would redesign markets to create scalable and credible mechanisms to fund carbon removals. Technology-based removals can be incentivised through the introduction of clean-up certificates into the EU emissions trading system, while nature-based removals would require improved market design centred on a new asset class: nature shares.

The four pillars reinforce each other. A multi-country CBAM and carbon pricing coalition (Pillar 1) would reduce the cost of financing power sector decarbonisation (Pillar 2). Linking EMDE membership of the CBAM and carbon-pricing coalition to financial support for the decarbonisation of power sectors would also make it more attractive for EMDEs to adopt carbon prices. Decarbonisation of power sectors (Pillar 2) would be a precondition for developing clean, highly energy-intensive industry in renewables-rich EMDEs (Pillar 3).

The Pillar 1 coalition should include the EU, China and as many other countries as possible. Advanced countries and China could underpin the Pillar 2 financier coalition. Pillar 3 would involve the EU and potentially other energy-poor advanced countries, along with EMDEs that are richly endowed with renewables. Pillar 4 would include the main custodians of the planet's natural capital. Enabling these coalitions will require EU leadership.

The EU and its climate finance coalition partners should offer conditional fiscal support to all developing countries (except China and oil and gas producers) that are willing to commit to net zero consistent decarbonisation of their power sectors

1 Introduction

The planet's future depends increasingly on emerging and developing economies. Advanced economies continue to matter because of their higher per-capita emissions, their shares of global trade and finance, and their influence through research, technology and diplomacy; but their share in global greenhouse gas emissions is shrinking.

Success in stopping global warming and halting biodiversity loss hinges on whether countries such as India, Indonesia, Brazil and South Africa adopt low-carbon, nature-positive development paths, and if they do so quickly. The same applies to China, which is both the world's top emitter of CO_2 and the country at the forefront of the green industrial revolution.

Geopolitical fragmentation, shifting priorities and a hostile United States administration are slowing the transition to a more sustainable economic model in line with the landmark Paris Climate Agreement of 2015. With climate and nature degradation accelerating, governments that understand the importance of climate and nature actions – still in the majority – are faced with hard questions.

Recent international discussions on climate change mitigation and the preservation of biodiversity have centred on ambitious targets and the closing of funding gaps. These remain important topics for negotiation but are no longer sufficient. Instead, a broader approach is required to connect mitigation with adaptation and the preservation of nature.

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

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

2 The case for action

In a darkening geopolitical landscape, the pace of technological innovation is a bright spot. Renewable energy and other green technologies have rapidly gained cost competitiveness and scale. Most new renewable power is now cheaper than fossil fuel alternatives. The IEA (2024), IRENA (2024) and Lazard (2024), among others[1], have shown that the levelised cost of electricity (LCOE) of unsubsidised solar and wind is often lower than that of fossil fuel-based electricity generation, especially when considering new power plant construction.

Solar photovoltaic (PV) costs have plummeted to roughly \$0.04 per kWh, making solar power more than 50 percent cheaper than generation from fossil fuels or nuclear plants (IRENA, 2024). Even accounting for network and backup costs, this is major progress that is bound to affect the energy pecking order.

This dramatic cost decline, alongside improvements in wind turbines and battery technology, means clean technologies offer better economic returns than coal or gas. In dollar terms, investment in renewables now outpaces fossil electricity investment by ten to one, with more investment in solar than in all other power sources combined.

Year-on-year global growth in electricity generation from solar PV was double the growth from all fossil fuels combined in 2024[2]. Other green technologies are also scaling quickly. Meanwhile, electric vehicle sales have risen from 3 million units in 2020 to 17 million units in 2024 (IEA, 2025).

But despite these developments, investment in new coal-fired power plants continues, particularly in China, which approved 106 gigawatts of new coal power capacity in 2022 alone – four times the amount approved in 2021[3]. Reasons for this include concerns about supply security, local support for coal and the high upfront cost of investment in renewables that many countries find difficult to finance.

Unless retired early, these coal plants will remain in operation for decades, locking in emissions far beyond 2030. Meanwhile, the global vehicle fleet remains overwhelmingly dependent on fossil fuels: in 2024, more than 95 percent of vehicles in circulation still had internal combustion engines[4].

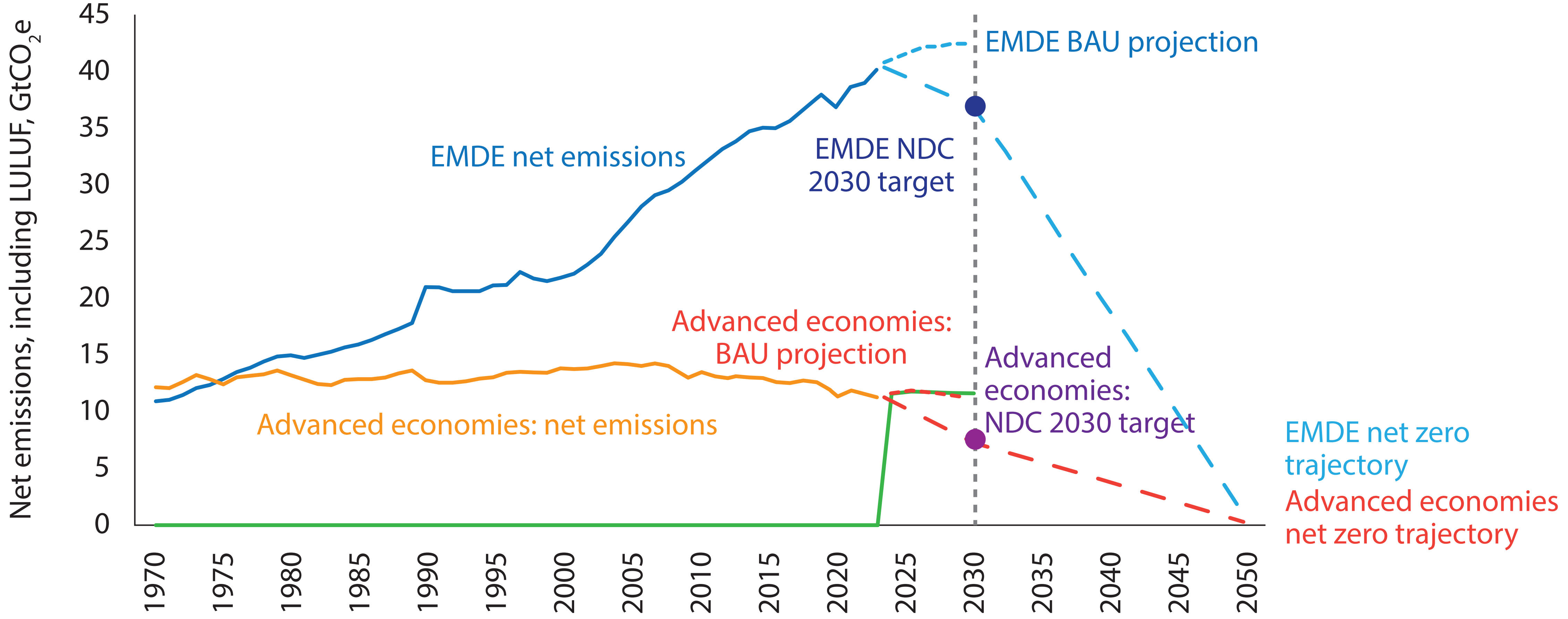
Consequently, climate policies and trajectories are far off the path needed to reach emissions targets compatible with the Paris Agreement's objective of limiting global warming to 1.5 degrees Celsius above pre-industrial levels. Continuing with today's policies is projected to lead to about 2.7°C of warming by 2100[5].

Moreover, aggregate projections mask stark differences between advanced and developing economies. Emissions in most advanced economies have already peaked and steady declines have begun. In contrast, emissions in many EMDEs are still rising, driven by economic and population growth and continued heavy reliance on coal, oil and gas.

As of 2023, EMDEs (including China) accounted for roughly two-thirds of global emissions. Their share is expected to grow further as they contribute the bulk of new emissions. Advanced economies account for a shrinking portion of annual emissions (for example, the EU and United Kingdom together now contribute only about 8 percent of global emissions).

Reaching global net zero emissions by 2050 requires a sharp break with the current emissions trend in EMDEs (Figure 1). Limiting global warming to 1.5°C would require an even more radical break, consistent with reaching global net zero emissions by the mid-to-late 2030s rather than 2050[6].

Figure 1. Historical emissions, 1970-2023, and requirements for reaching net zero in 2050



*Note: several countries, including China and India, have set less ambitious targets. * EMDEs includes China. The 2050 projection is given for EMDEs as a whole and not separately for China. BAU = business as usual; NDC = Nationally Determined Contribution; LULUCF = land use, land-use change and forestry.*
Source: Grabbe et al (2025).

EMDEs are also custodians of much of the planet's natural capital, so that collective climate outcomes are intertwined with how those countries manage nature and biodiversity. Many of the world's critical carbon sinks and biodiversity hotspots (including tropical forests and wetlands) are located in developing regions across Latin America, Africa and Asia.

These ecosystems bolster climate resilience by absorbing CO_2 and providing a buffer against extreme weather. Conversely, their destruction would accelerate climate change and undermine adaptation efforts. Nature-based solutions, such as reforestation and ecosystem restoration, could provide 20 percent to 30 percent of the emissions reductions needed to limit warming to 1.5°C (chapter 7 in IPCC, 2022).

However, continued deforestation or ecosystem collapse (for instance, of the Amazon rainforest) would release vast amounts of carbon and destabilise regional climates. Climate change and biodiversity loss are mutually reinforcing: climate change is now a leading driver of biodiversity loss, and in turn the erosion of biodiversity undermines natural carbon sinks and ecosystem resilience. It follows that preserving nature – alongside cutting emissions – is essential for climate stability and nature sustainability.

The costs of the green transition and of restoring/protecting nature in emerging economies are often disproportionately high relative to their GDPs and fiscal capacities. Our best guess estimates of the investments needed are far above current investment levels in EMDEs (excluding China).

In practice, annual clean-energy investment in developing regions would need to more than quadruple from 2022 levels by 2030. This would be unprecedented. It reflects the reality that many EMDE economies are both carbon-intensive (hence requiring more investment to decarbonise) and growing rapidly (hence needing more energy infrastructure overall).

Financing these investments is challenging because of the high cost of capital in EMDEs. Capital for clean energy projects is considerably more expensive in developing markets, reflecting higher macroeconomic risks, regulatory and political uncertainty, and less developed financial systems (Berglof *et al* 2025; Fornaro *et al* 2025; Sen, 2025).

For example, in 2021 the real cost of capital for a utility-scale solar PV project was about 3 percent in Europe and the US, but roughly 7 percent in India and Mexico, over 9 percent in Brazil and as high as 10 percent to 15 percent in sub-Saharan African countries (IEA, 2023). This steep disparity in financing costs greatly inflates the levelised cost of renewable energy in emerging economies, often offsetting their natural advantages, such as abundant solar irradiation.

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

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

One of the main problems with the widely cited finance gap estimates is that they are rarely accompanied by credible strategies to close them. Instead, these figures are often presented as arguments to mobilise funding, particularly from the private sector or through blended finance mechanisms.

However, as the disparity between estimated needs and actual flows increases, the effectiveness of gap estimates as mobilisation tools diminishes. Rather than galvanising action, they risk fostering resignation – or worse, a new form of denial, whereby the evidence from climate science may no longer be questioned but the policies needed to combat climate change will.

In wealthier countries, particularly those in temperate climate zones, this can lead to a quiet acceptance of failure and a shift in focus to adaptation, the implicit message being that the battle has been lost.

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

- A disjointed approach to address highly connected issues: although the containment of global warming and the preservation of nature are linked in multiple ways, they are mostly tackled separately.

- The fraying of multilateralism: the previous remedy to the shortcomings of a disjointed approach would have been to embrace a more holistic strategy, yet nationalism and geopolitical tensions hamper the search for encompassing solutions.

- A lack of adequate incentives: developing countries (for their mitigation efforts) and advanced countries (for their contributions to the financing of these efforts) both face collective action problems, but incentives are not adequately aligned.

To address these problems, a robust and realistic architecture is needed. In the current geopolitical context, such an architecture must be flexible, recognising that a requirement for agreement by consensus will hold the transition back and will give too much say to those that are dragging their feet.

Coalitions of countries that are ready to move more quickly offer the best way forward, and are more likely to align incentives. We propose a redesign based on four pillars:

- Pillar 1: A tiered carbon pricing coalition with a common carbon border adjustment mechanism (CBAM);
- Pillar 2: A scaling-up of climate finance, conditional on effective decarbonisation commitments;
- Pillar 3: Green industrial partnerships between advanced and developing countries;
- Pillar 4: An effective market architecture for large-scale carbon removal and nature restoration, to complement public funding.

3 A four-pillar strategy

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

The 2015 Paris Agreement achieved near-universal participation, with 196 countries agreeing to commit to climate action. This broad involvement was unprecedented, particularly compared to earlier agreements such as the Kyoto Protocol, in which not all developed nations participated (Guérin and Tubiana, 2025).

Unlike previous top-down approaches, Paris allowed countries to determine their own climate commitments, making it politically feasible for many countries to join and offer pledges according to their capabilities. EMDEs could present both unconditional and conditional targets, explicitly linking goals to financial support from rich countries.

Subsequent climate summits have also introduced systematic transparency measures, requiring regular progress reports on emissions reductions, with peer review and pressure.

Ten years on, the Paris Agreement pledges formulated by countries (their Nationally Determined Contributions, or NDCs) make it possible to assess if they add up to the level of effort required to halt global warming (they do not). However, there is no binding enforcement mechanism to ensure that countries meet their commitments.

The Paris Agreement cannot adequately address the free-rider problem associated with emissions: the benefits of emissions reductions are global, but the costs are borne by each country.

The second withdrawal of the United States from the Paris Agreement, in January 2025 at the direction of the re-elected President Trump, was a significant setback. But it is also a strategic opportunity for other nations to strengthen international climate cooperation.

The absence of the US from global climate negotiations could enable the European Union and other major global economies such as China, Brazil and India to agree ambitious and coherent international climate strategies, without needing to accommodate constraints created by US domestic politics and preferences. At the same time, it is important that any agreement should be open to future US participation.

Scaling-up effective climate action requires a stronger link between climate policies and trade[7]. We propose, building on Clausing *et al* (2025), that international collaboration take the form of an open and inclusive 'climate coalition'. Membership obligations would include:

1. Adoption of a tiered carbon pricing mechanism; and

2. Adoption of a common carbon border adjustment mechanism (and no carbon border adjustment within the coalition).

The EU decision to introduce a carbon border adjustment mechanism (CBAM) would be an incentive for countries to join the club of climate-ambitious countries. They would gain CBAM exemption, along with possible additional incentives involving technology transfer, climate finance, technical assistance, and clean energy trade liberalisation.

Club members would commit to enforce domestic carbon pricing through taxation or equivalent emissions trading systems. They would also adopt CBAMs that impose tariffs equivalent to their domestic carbon prices on imports from non-member nations. This would reduce carbon leakage and maintain competitive fairness.

Importantly, Clausing *et al* (2025) propose that participation be structured through a tiered carbon pricing system, such as that proposed by the International Monetary Fund (Parry *et al* 2021). For example, lower-income countries could implement lower carbon price floors (eg. €25 per tonne), middle-income countries would be requested to adopt a higher, but still moderate level (eg. €50 per tonne) and higher-income economies would have higher rates (at least €75 per tonne), with prices adjusted regularly for inflation. Other variations, including differentiation between lower and upper middle-income countries, could also be considered.

This differentiated approach aligns with the principle of common but differentiated responsibilities, a cornerstone of previous global climate agreements, and addresses equity concerns by mitigating potential economic impacts on developing nations.

The differentiated schedule should serve as a transitional measure, with carbon tax rates increasing as countries achieve higher levels of income. This expectation of carbon price convergence should reduce incentives for carbon-intensive industries to relocate to jurisdictions with lower carbon prices. Both the levels of the tiers and the pace of convergence would be subject to negotiation (Clausing *et al* 2025).

The coalition would initially focus on the carbon-intensive goods included in the EU CBAM: aluminium, iron and steel, cement, fertilisers and hydrogen production. These industries comprise a significant share of global carbon emissions (about 20 percent), including both direct emissions and the emissions from the electricity used in their production.

But the CBAM could be enlarged if similar measures are adopted by other countries, for example in East Asia, and be broadened if other goods end up being added to the intermediate products of the initial list.

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

This proposed climate club would complement the United Nations Framework Convention on Climate Change Conference of the Parties (COP) process by deepening collaboration among coalition members – primarily because it relies on reciprocity and meaningful incentives rather than voluntary commitments and peer pressure.

Countries would gain economic benefits from participation and the reciprocal structure would incentivise sustained participation and climate action, while addressing carbon leakage and competitiveness concerns.

A viable coalition should quickly expand from the EU and its main suppliers to other large countries, including China, Korea, Japan, India, South Africa and Brazil. These countries are, of course, at very different stages of development, and their respective incentives will need to be calibrated carefully.

In addition to a tiered schedule for carbon pricing, the design should include commitments to technology transfer and financial support for green transitions in lower-income countries. In light of concerns about industrial overcapacity in sectors such as steel, it may also require an agreement to limit or eliminate subsidies. The EU would need to play a leading role in establishing this framework.

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

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

A way out of this conundrum would be to form 'climate finance coalitions' involving subsets of advanced countries willing to fund decarbonisation in the South and subsets of developing countries willing to decarbonise their economies if given access to funding on reasonable terms (Bolton and Kleinnijenhuis, 2025).

This mutual commitment would be in the self-interest of all participating countries: all would gain from the avoidance of physical, health and economic damage thanks to lower emissions in EMDEs, while economic benefits would be roughly in proportion to countries' GDP.

As a result, fiscal support for the decarbonisation of EMDEs (except China) would be in the economic interest of advanced countries and China, even if EMDEs do not contribute (Bolton and Kleinnijenhuis, 2025).

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

For a funding coalition that excludes the US but includes China, the EU, Canada, Japan, South Korea and some additional smaller industrial partners, the fiscal burden would be about 0.2 percent of GDP. If China is also excluded from the financier coalition, the cost would rise to 0.3 percent of GDP/year.

The greater the economic damage from climate change, the smaller the critical mass of participants would need to be for coalition financing to be profitable. But even if global economic damage (the social cost of carbon) were relatively low ($190/tCO2, as assumed by Rennert *et al* 2022), a financier coalition consisting of the EU and advanced countries except the US would benefit economically from financing the decarbonisation of most of the largest developing country power sector emitters.

If the US or China were to join, the coalition would find it in its interest to finance the decarbonisation of almost all developing country emitters. If the assumed damages are significantly higher, as argued by Bilal and Känzig (2025), large entities including the EU, China (and the US) would find it profitable to embark on decarbonisation support alone, even if not joined by other partners.

Under the Paris Agreement, all signatories must offer new NDCs at COP30 in Brazil in November 2025. With the next versions not due until 2030, this set of NDCs represents the last chance to put emissions on a net-zero consistent path.

The EU and its climate finance coalition partners should offer conditional fiscal support to all developing countries (except China and oil and gas producers) that are willing to commit to net zero consistent decarbonisation of their power sectors. While only accounting for about 40 percent of developing countries' emissions, power sector decarbonisation is a necessary step for the decarbonisation of industry and transport.

3.3 Pillar 3: Green industrial partnerships between the EU and developing countries

Europe currently imports most of its oil and gas at relatively high cost. The continent's transition to clean energy will end its dependency on imported fossil fuels, but not its relative energy scarcity (McWilliams *et al* 2025). Europe is not well-endowed in green energy.

Limited land availability and a relatively poor solar potential (except in Southern Europe) imply that the cost of producing electricity will be higher than in countries on the other side of the Mediterranean, in the Middle East or in Africa.

Nuclear power can help, but not to the point of eliminating Europe's structural cost disadvantage, as nuclear is relatively expensive compared to renewables once the possibility of electricity storage is factored in.

As a result, Europe will remain an energy importer in the medium and possibly long terms. However, transporting electricity is much more costly than transporting fossil fuels, even taking into account the possibility of producing hydrogen and transporting it by sea or through pipelines.

In contrast, energy-intensive intermediate products in the value chains of the chemical and steel industries, such as ammonia, fertilisers, methanol and reduced iron, can be easily and cost-effectively transported by sea.

For this reason, the green transition is bound to transform the international division of labour along value chains. Developing country exporters of primary products such as iron ore are likely to move down the value chain and export processed products, such as direct reduced iron, instead of raw commodities.

Consequently, some upstream segments of European energy-intensive industries (EIIs) would move South. This restructuring of global value chains would be economically efficient and would help the industrialisation of the South.

To the extent that energy-intensive intermediate inputs, such as ammonia or direct reduced iron, are produced with green electricity or green hydrogen, it would also lead to significant greenhouse gases emission reductions.

This leaves two important questions unanswered:

1. How to ensure that the migration of energy-intensive production supports Europe's own green industrialisation goals and, more broadly, its efforts to improve its competitiveness and its economic security; and

2. How to ensure that it results in global emissions reductions, rather than simply carbon leakage from the EU to the Global South.

McWilliams *et al* (2025) seek to answer both questions. On the first, they argue that the direct value added and employment loss of the relocation of energy-intensive intermediate products to the South would be modest. In Germany, EIIs account for most industrial energy demand but only 5 percent of manufacturing wages and 6 percent of the value added. The upstream segments of those industries represent a fraction of those numbers.

At the same time, relocating these production stages should not only boost the competitiveness of downstream EII segments, but also industrial competitiveness more broadly, by reducing energy costs. Substituting domestic production of ammonia, methanol and reduced iron by imports could reduce EU electricity demand by around one-quarter of today's green electricity production in the EU, and around one-tenth of 2050 projected demand

(McWilliams *et al* 2025). The ensuing impact on EU energy prices would benefit industrial consumers, households and the public purse.

The policy implications are two-fold. First, while subsidies to modernise and protect European heavy industry can be justified both by the green transition and by the need to retain potentially competitive industry in a context of possible Chinese overcapacity, public money should both be conditional on abatement efforts and go to less-energy-intensive downstream industries, rather than highly energy-intensive intermediate products.

This requires a revamping of the EU Clean Industrial Deal, which does not presently discriminate between production stages that should remain in the EU in the long term and those that need not.

Second, EU industrial policy must be linked to trade, investment and climate policies that embed low-cost energy intensive production in developing countries into EU value chains. The two pillars of EU climate policy discussed above – an EU-led carbon pricing and CBAM coalition, and an EU-led coalition to fund decarbonisation of power sectors in developing countries – are critical in this regard.

In addition, Clean Trade and Investment Partnerships, as announced by the European Commission (Jütten, 2025), would need to be set up to both improve market access to the EU and transfer technology to those developing countries that have the potential to be reliable suppliers of green-energy-intensive intermediate products.

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

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

It is almost certain that the world will overshoot climate targets. This makes investment in negative emissions essential. Limiting global warming to below 1.5°C does not rely only on the containment of emissions, but also on large-scale deployment of carbon dioxide removal (CDR) technologies of all kinds. Some models project gross CDR volumes of 10 to 20 $GtCO_2$ per year by the second half of the twenty-first century, equivalent to one-quarter to one-half of today's global emissions (Hoegh-Guldberg *et al* 2018).

Negative emissions can be achieved through natural sequestration, which relies on photosynthesis and ecosystem processes (eg. afforestation, soil carbon, carbon stored in coastal and marine ecosystems), and technological solutions that extract CO_2 from the atmosphere, such as direct air capture and storage (DACS), which does not yet exist at scale.

This pillar proposes two market innovations:

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

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

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

3.4.1 A market mechanism for negative emissions: clean-up certificates

Following Edenhofer *et al* (2025), we propose a new market-based instrument in the form of clean-up certificates, designed to embed CDR into the EU ETS and make the financing of net-negative emissions feasible at scale. The certificates would offer firms a legal right to emit beyond their allowances today, in exchange for an obligation to remove the equivalent amount of CO_2 from the atmosphere in the future. This creates a form of carbon debt, explicitly linked to future removals.

The EU ETS is approaching a structural turning point. Under current rules, the last allowances for energy and industrial sectors will be auctioned around 2039. Yet some residual emissions – particularly in hard-to-abate sectors such as cement – will remain too costly or infeasible to eliminate. Without a mechanism to offset these emissions, carbon prices could spike in the 2040s, undermining the predictability and effectiveness of the EU ETS.

Moreover, firms are already making forward-looking investment decisions and are banking certificates. Introducing clean-up certificates now would enable regulated entities to anticipate future compliance costs, while generating demand and finance for removals today.

The institutional redesign would involve two steps:

1. Issuance of clean-up certificates: these certificates would authorise emissions today but create a carbon debt obligation to remove the equivalent CO_2 in the future.

2. Creation of a European Carbon Central Bank (ECCB), which would oversee the issuance, verification and enforcement of carbon debt contracts. It would act as a regulatory and financial anchor, ensuring transparency, risk management and intertemporal consistency in carbon markets.

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

Time-inconsistency is obviously a major concern. Without safeguards, firms might bet on an excessively high pace of technological progress, become overindebted and end up defaulting on their carbon debt. To prevent such outcomes, Edenhofer *et al* (2025) propose to grant the European Commission the option of intervening in the market by limiting the amount of clean-up certificates.

In addition, reducing the issuance of conventional allowances would increase overall ambition levels as a result of the overall cost reductions from introducing clean-up certificates. To insure against corporate bankruptcy, Edenhofer *et al* (2025) propose that firms issuing carbon debt post collateral in the form of security deposits at the ECCB.

If the firm delivers the expected certified removals, the deposit is released. If it defaults, the ECCB retains the funds and uses them to procure equivalent removals elsewhere.

The EU ETS should thus evolve from a pure mitigation instrument into a tool that manages the entire carbon cycle. Over the longer run, negative emissions from nature-based removals could be integrated, potentially as a separate category of clean-up certificate. The potential for such removals is particularly high in EMDEs and in low-income countries, which also host significant biodiversity.

However, two conditions must be met: nature-based removals must be additional and permanent. Achieving this requires a fundamental redesign of nature markets, which we address next.

3.4.2 A market for natural provision of negative emissions and nature restoration

Cantillon *et al* (2025) propose a novel design for nature markets to scale up carbon removals and nature restoration in the Global South. The aim would be to overcome the high transaction costs, low credibility and short-termism that characterise the current voluntary carbon markets. The proposed mechanism would address these design flaws through four innovations:

1. Jurisdictional scale: projects would be defined at regional or provincial level rather than small-scale private projects. This scale would reduce leakage, improve monitoring and enhance additionality by aligning with regulatory boundaries. Jurisdictions would compete to attract capital.

2. Equity-based instruments: instead of issuing credits, jurisdictions would sell shares in a portfolio of nature-based projects. These shares would entitle holders to receive 'dividends' in the form of measured carbon and biodiversity benefits (eg. a quantity of avoided CO_2, increase in biodiversity). Dividends would be released prudently over time, with buffers to account for ecological risk. This would allow for permanent claims without assuming permanence in ecological systems.

3. Primary market as a crowdfunding mechanism: jurisdictions would list projects with detailed descriptions and minimum funding thresholds. Investors would allocate capital across proposals. Prices would form endogenously, with projects that attract excess demand seeing rising share prices, while underfunded projects would be delisted. This competitive mechanism would incentivise jurisdictions to improve project quality and additionality.

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

The proposed share-based model would address the main shortcomings of credit markets by realigning incentives and embedding long-term commitment. Unlike credit buyers, shareholders would internalise ecological risk, fostering better stewardship and accounting for the impermanence of natural systems. Jurisdictional project scope and competitive pricing would enhance additionality and minimise leakage.

By pricing a bundle of project attributes, the model would generate implicit values for biodiversity alongside carbon. Centralised governance and larger project scale would reduce transaction costs, while the secondary market would ensure liquidity. Overall, the approach should shift the market from transactional offsetting to long-term ecological investment.

To scale up, the market would require reliable demand. Rather than relying solely on offsets, a boost to demand could come from mandating institutional investors to align the carbon footprints of their portfolios with the Paris-aligned trajectories (and to do the same with their biodiversity footprints when such standards are established) and authorise them to use nature shares (on top of any other asset reshuffling) to meet this goal.

A major advantage of acting at the level of funds, rather than the underlying companies, is that it would not release these companies from any existing or upcoming obligations to decarbonise and reduce their biodiversity impacts.

While the model is well suited for provision projects, conservation is harder to finance because it delivers no flow of carbon and no added biodiversity dividends. The benefits of conservation are in the preservation of stocks of carbon and biodiversity. Cantillon *et al* (2025) discuss different ways to address this: 1) conservation projects could be integrated into the mechanism, which would facilitate private funding but complicate the design, or 2) it would require a separate funding mechanism, as proposed for the Amazon (see Box 1). In addition, nature-harming subsidies should be eliminated.

4 Robust governance

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

For eight decades, the management of global commons has relied on a more-or-less stable template of almost all countries signing up to multilateral treaties, the implementation of which rested on global institutions. For example, international trade was governed by the multilateral General Agreement on Tariffs Trade rules, guided by the 166-member World Trade Organisation.

Similarly, rules for international capital flows and exchange rate policies were enshrined in the Articles of Agreement of the IMF (191 members), which is also in charge of enforcing them. The same has applied to many other fields, including climate action (195 signatories) and the protection of biodiversity (also 195 signatories).

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

- Participation in global governance arrangements increasingly departs from the principle that sovereign states have exclusive control over their territory and their citizens and, accordingly, no right to interfere in another sovereign state's affairs, except through international agreements, while private and subnational

Box 1: reforestation and conservation of the Amazon

The Amazon rainforest is crucial for both capturing carbon and preserving biodiversity. Assunção and Scheinkman (2025) explore two complementary approaches to finance tropical forest protection in the Amazon: (1) reforestation of previously deforested areas, and (2) conservation of standing forests.

Reforestation – especially through natural regeneration – is shown to be a low-cost and high-impact carbon-removal strategy. In the Brazilian Amazon, approximately 50 million hectares of currently deforested land could capture up to 23 gigatonnes (Gt) of CO_2 over the next three decades. Assuming international payments of $25/tonne of CO_2, this reforestation could generate $572 billion in gross transfers. After adjusting for land-use change costs, lost cattle production and discounting, the net benefit to Brazil is estimated at $282 billion in present value over 30 years, while delivering 18 Gt in net carbon capture, and avoiding 16 Gt of currently foreseen emissions.

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

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

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

actors can only intervene in the affairs of others through their national governments. However, the Paris Agreement relies to a great extent on non-state actors such as subnational entities (regions and cities) (Guérin and Tubiana, 2025). Many subnational governments have adopted targets and implemented policies that exceed the national ambition. Moreover, civil society, business associations and major private corporations all play a role in the climate governance process.

- Beyond the climate field, ways have been found to ensure the effectiveness of cooperation without relying on mandatory global rules. For example, international cooperation on banking regulation takes place within the framework of the Basel Committee on Banking Supervision, but standards set by this committee are not legally binding on financial institutions or national supervisors. Each country remains free to legislate on financial safety matters, though knowing that the Basel Committee regularly assesses national regulatory frameworks and publishes its findings. This mechanism has so far proved effective in ensuring global financial oversight and improving financial stability.

- Specialised public agencies, such as central banks and regulatory authorities, have developed new forms of cooperation that do not directly involve national governments but rest on the similarity of the mandates of institutions to put in place effective arrangements. A particularly telling example is that of competition authorities, which have found a tacit understanding on their respective scope of extraterritoriality and have accordingly developed new modes of cooperation[8].

Patterns of effective international cooperation have therefore become much more diverse, and further innovations can be proposed. Examples include the suggestion by Guérin and Tubiana (2025) to give formal status to the involvement of subnational actors by involving them in periodic climate change mitigation assessments; the proposal by Cantillon *et al* (2025) that subnational jurisdictions issue shares that depend for their value on nature preservation performance in their territory; and the plan by Edenhofer *et al* (2025) to entrust a carbon central bank with the mandate of overseeing the market for carbon removals.

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

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

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

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

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

1. The potentially widest is the climate coalition corresponding to Pillar 1 of the previous section, members of which would adopt carbon pricing differentiated by the level of development and establish a common CBAM of the type being implemented by the European Union (Clausing *et al* 2025). Membership should include all countries that have adopted or consider adopting carbon pricing, including China.

2. Next comes a climate finance alliance of advanced industrial countries, plus China, to promote the decarbonisation of the power sectors of as many developing countries as possible (Pillar 2). This coalition could be linked to the architecture of the Paris Agreement by offering sufficient financial support to fund the phase-in of a renewable energy pipeline to all countries that are willing to commit to: (1) net zero consistent power sector transformation in their 2025 conditional NDCs; (2) milestones for the phase out of fossil-fuel power sources; and (3) a governance structure to identify and monitor renewables projects and the early closing of fossil fuel power assets.

3. Green industrial partnerships (Pillar 3) would at a minimum require participation by the EU and a set of developing trade partners endowed with large renewable energy potential. But this coalition should welcome the entry of additional advanced energy importers of steel, chemical and other energy-intensive industries, such as Japan, South Korea, and the UK, and their main developing trade partners. The partnership should be open to

both advanced and developing counties, and could significantly overlap with other coalitions. But there will be differences, at least initially. While it is essential that China belongs to the plurilateral CBAM (point 1 above and Clausing *et al* 2025), and while it is desirable that it belongs to the climate finance coalition, climate finance could go ahead without it. More importantly, adopting a carbon price should not be a condition for advanced country financial support for power sector decarbonisation, but it would be a condition for membership of the plurilateral CBAM.

4. Creating nature finance at scale will require a coalition of countries that are custodians of the world's most biodiverse ecosystems (Pillar 4). Together, they would participate in a credible mechanism to support large-scale nature restoration and carbon removal by offering nature shares. To succeed, the issuance of these shares should be matched by stronger demand for them – ideally led by a group of advanced countries. The EU could play a pivotal role by fostering the decarbonisation of investment portfolios.

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

- Membership of the plurilateral CBAM/carbon price coalition (Pillar 1) would create a price-based incentive to decarbonise the power sector that reduces the need for fiscal subsidies, thereby lowering the fiscal burden shouldered by the members of the financier coalition in supporting decarbonisation in the Global South (Pillar 2);

- Financial support for power sector decarbonisation (Pillar 2) and trade and investment partnerships between EMDEs and the EU (Pillar 3) could make membership of the CBAM/carbon price coalition (Pillar 1) more attractive for EMDEs;

- The decarbonisation of EMDE power sectors, envisaged in Pillar 2, is a pre-condition for the outsourcing of highly energy-intensive production stages to EMDEs with abundant renewables endowments, as envisaged in Pillar 3.

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

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Endnotes

1. See also Wood Mackenzie press release of 21 October 2024, 'Global Competitiveness of Renewable LCOE Continues to Accelerate'.
2. Authors' calculations based on the Ember electricity dashboard.
3. Reuters, 'China's new coal plant approvals surge in 2022, highest since 2015 – research', 27 February 2023.
4. Hannah Ritchie, 'Tracking global data on electric vehicles', Our World in Data, February 2025
5. Climate Action Tracker, 'Emissions Pathways', November 2024 update
6. According to the Potsdam Institute for Climate Impact Research's 'carbon clock', the remaining 1.5°C-consistent carbon budget is just 173 gigatonnes (Gt) of CO_2 (about five times 2023 emissions), while the remaining 2°C-consistent carbon budget is 923 Gt. The cumulative emissions implied by the net zero scenario shown in Figure 1 are about 525 Gt of CO_2, consistent with a global temperature rise of about 1.7°C – a dangerously high level given the risk of climate tipping points even for a 1.5°C rise (Armstrong McKay et al 2022).
7. G7 Leaders' Statement of 12 December 2022.
8. For a recent review of global governance arrangements, see Papaconstantinou and Pisani-Ferry (2024).
9. 'Secretary-designate Marco Rubio, SFRC Confirmation Hearing Opening Remarks', 15 January 2025.
10. US Department of the Treasury press release of 23 April 2025, 'Treasury Secretary Scott Bessent Remarks before the Institute of International Finance'.

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This Policy Brief distils some of the main messages of the Paris Report 2025, a joint initiative by Bruegel and CEPR (Pisani-Ferry et al 2025). This year's focus is on accelerating the energy transition and restoring nature in emerging and developing economies. We thank all Paris Report contributors, and Patrick Bolton, Kim Clausing, Ignacio Garcia Bercero, Heather Grabbe, Alissa Kleinnijenhuis, Matthias Kalkuhl, José Scheinkman and Simone Tagliapietra for comments on an earlier draft. This article is based on Bruegel Policy Brief Issue no17/25 | July 2025.

Reconciling the EU's goals with those of the Global South

Clean industrialisation is a political and economic priority for the EU. Ben McWilliams, Simone Tagliapietra and Jeromin Zettelmeyer argue that importing energy-intensive goods would be more efficient for EU clean industry goals than importing clean energy itself

Executive summary

Clean industrialisation is a political and economic priority for the European Union. For it to work, affordable clean energy is needed. However, producing this energy in Europe is constrained by limited renewable energy endowments (sunshine and wind) and land availability, while the transportation costs for imported clean energy (in the form of electricity or hydrogen) are much higher than for fossil fuels.

An alternative way to fuel Europe's clean industrial sector would be to import energy-intensive primary tradeable products such as ammonia, methanol and reduced iron. We estimate that more than ten percent of total future EU clean energy demand will be met by such products.

Public policy in Europe should aim to facilitate trade in energy-intensive intermediate inputs, which are cheaper to import that energy directly. Imports of these inputs could boost the competitiveness of downstream stages in the energy-intensive value chain (such as steel production). By lowering overall energy demand and thus electricity prices, such imports would also raise EU competitiveness more broadly.

In many cases, they would replace imports of less energy-intensive commodities such as iron ore, therefore not adding to Europe's overall import dependency. The direct economic impact in terms of jobs and value added that would be offshored is not substantial.

The international benefit of such a strategy would be that it would embed third countries – especially emerging and developing economies – into clean industrial value chains. Stable European demand can help such countries develop export-driven, clean industrial strategies. Politically, this could be an important incentive that could offset the EU's carbon border adjustment mechanism.

Governments should therefore not use taxpayer money to fight the relocation of energy-intensive and tradeable primary products, beyond some minimum threshold that is desirable for economic security and innovation reasons. Meanwhile, ongoing negotiations with third countries to establish Clean Trade and Investment Partnerships should put trade in energy-intensive clean products at the core of new international clean supply chains.

The EU wants to expand green manufacturing and retain heavy industry in decarbonised form – exactly the growth model successfully pursued by China in the last decade

1 Introduction

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

The European Union wants to boost production from green energy-intensive industries and increase domestic manufacturing of clean technologies needed for the energy transition to 40 percent of consumption by 2030[1]. The European Commission's February 2025 Clean Industrial Deal (European Commission 2025a), building on Draghi (2024), seeks to reconcile decarbonisation and industrial strength by *"lowering energy prices, creating high quality jobs and the right conditions for companies to thrive."*[2] An accompanying Affordable Energy Action Plan (European Commission 2025b) seeks to ensure cheap green energy for European manufacturing industries[3].

But expanding green manufacturing and retaining or expanding heavy industry in decarbonised form is exactly the growth model successfully pursued by China in the last decade. Many developing countries want to emulate this, including India, which wishes to raise its share of manufacturing in value added (Sen 2025).

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

While the EU has taken more measured steps – by, for example, imposing countervailing duties on Chinese electric vehicles and putting in place a carbon border adjustment mechanism, both of which are arguably consistent with World Trade Organization rules – even these are viewed as protectionist by China and by countries such as India (Sen 2025).

Second, inconsistent national industrial development plans imply that proposed strategies for international decarbonisation may be politically unfeasible. For example, a major expansion of international climate finance, funded by a coalition of advanced countries can be shown to be in the economic interests of the coalition, as measured by the coalition's share of the avoided global social cost of carbon (Bolton *et al* 2024; Bolton and Kleinnijenhuis 2025). But fiscal transfers in support of green growth in the South will hardly be politically feasible if viewed as threatening the industrial growth ambitions in the financier countries.

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

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

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

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

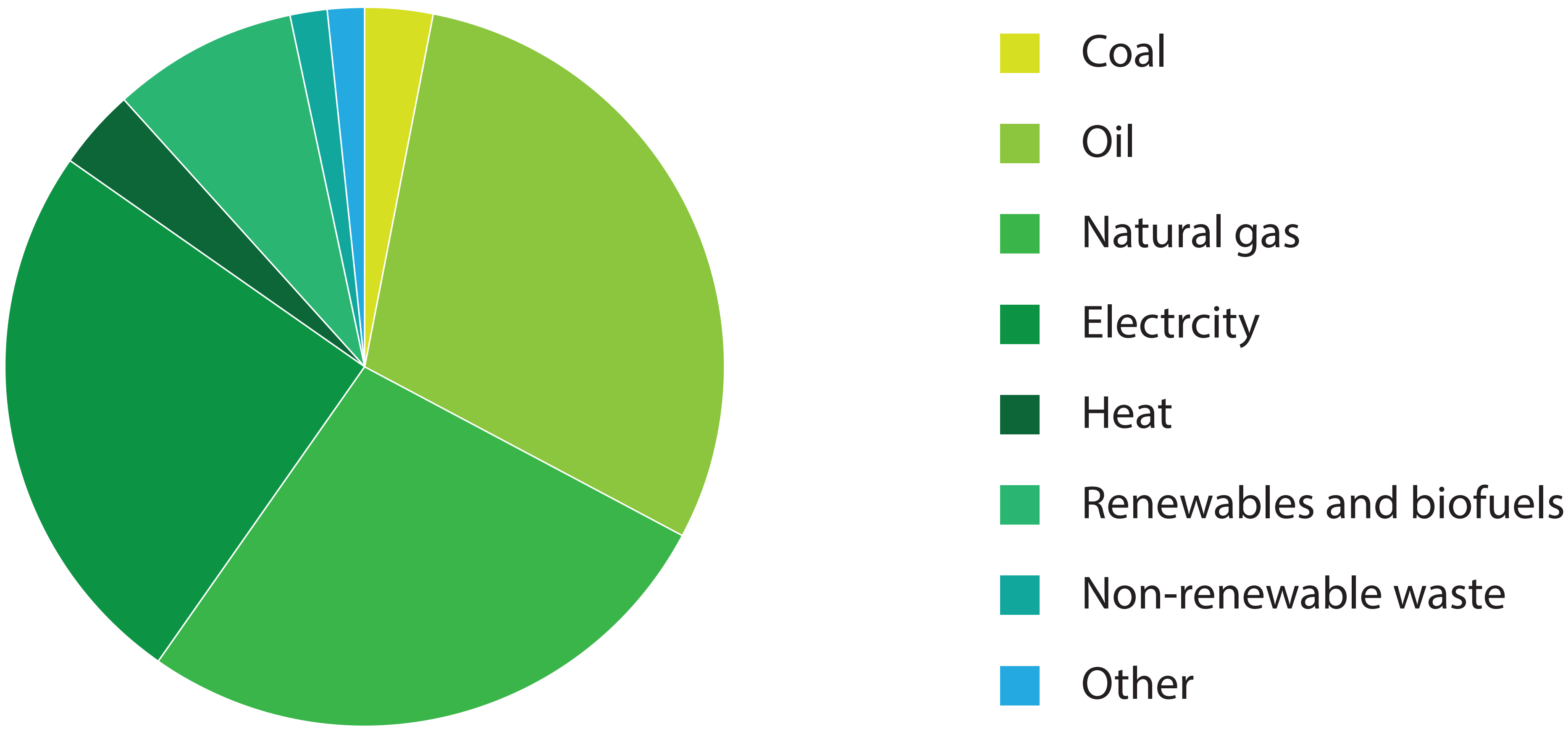
2 Green industrialisation in the European Union

Two-thirds of the energy products consumed by European industry come from oil products, natural gas and coal (Figure 1)[4]. There is little extraction of fossil fuels in Europe, so almost all of these energy products are imported. Green European industrialisation involves substituting these imports for new industrial processes powered by green energy. Europe's future industrial competitiveness will depend on the price of this green energy.

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

Industrial strategies in Europe rely on these three approaches to varying degrees. The European Commission's strategy, including the Clean Industrial Deal, is focused mostly on domestic production, particularly after the 2022 Russian invasion of Ukraine and the ensuing energy crisis illustrated the dangers of dependence on imported energy sources. Modelling from the European Commission (2024) on achieving climate neutrality in 2050 sees negligible volumes of direct electricity imports and overall energy import dependency falling dramatically.

Figure 1. Industrial demand for energy commodities, EU 2023



Source: Bruegel based on Eurostat.

However, non-electricity energy imports would continue to play a role at EU level, particularly for energy value chains involving hydrogen, a focus of the EU's 2020 hydrogen strategy (European Commission 2020). At the level of EU member states, hydrogen imports play a disproportionate role in Germany, where the government hydrogen strategy foresees hydrogen imports accounting for 50 percent to 70 percent of total domestic hydrogen demand.

The idea that it might make sense to import energy in the form of intermediate products has received less political attention – perhaps because it requires accepting the principle that Europe might need to offshore at least some energy-intensive production traditionally done in Europe.

However, the energy price hikes of 2022 have already prompted the offshoring of some particularly energy-intensive intermediate products, such as ammonia. Furthermore, both Germany's hydrogen strategy and the EU's RePowerEU (issued after Russia's invasion of Ukraine to wean the EU off Russian energy imports) plan include hydrogen derivates (such as ammonia) in hydrogen imports (BMWK 2023; European Commission 2022).

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

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

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

2.1 Europe's green energy endowments are relatively poor

The EU needs much more green energy. In 2023, the bloc produced 1,810 TWh of clean electricity[5]. Modelling by the European Commission (2024) suggested that 6,300 TWh to 7,000 TWh of clean electricity will be required by 2050 to reach net zero. This implies annual growth in clean electricity of 165 TWh compared to annual growth of 17 TWh since 2020.

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

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

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

While nuclear energy can play an increasingly important role in supporting electrification in Europe – particularly by providing much-needed low-carbon dispatchable power to complement the variability of renewables – it remains a relatively costly way of compensating for the continent's limited renewable energy endowment. The levelised cost of electricity for new nuclear in advanced economies remains significantly above that of solar and wind.

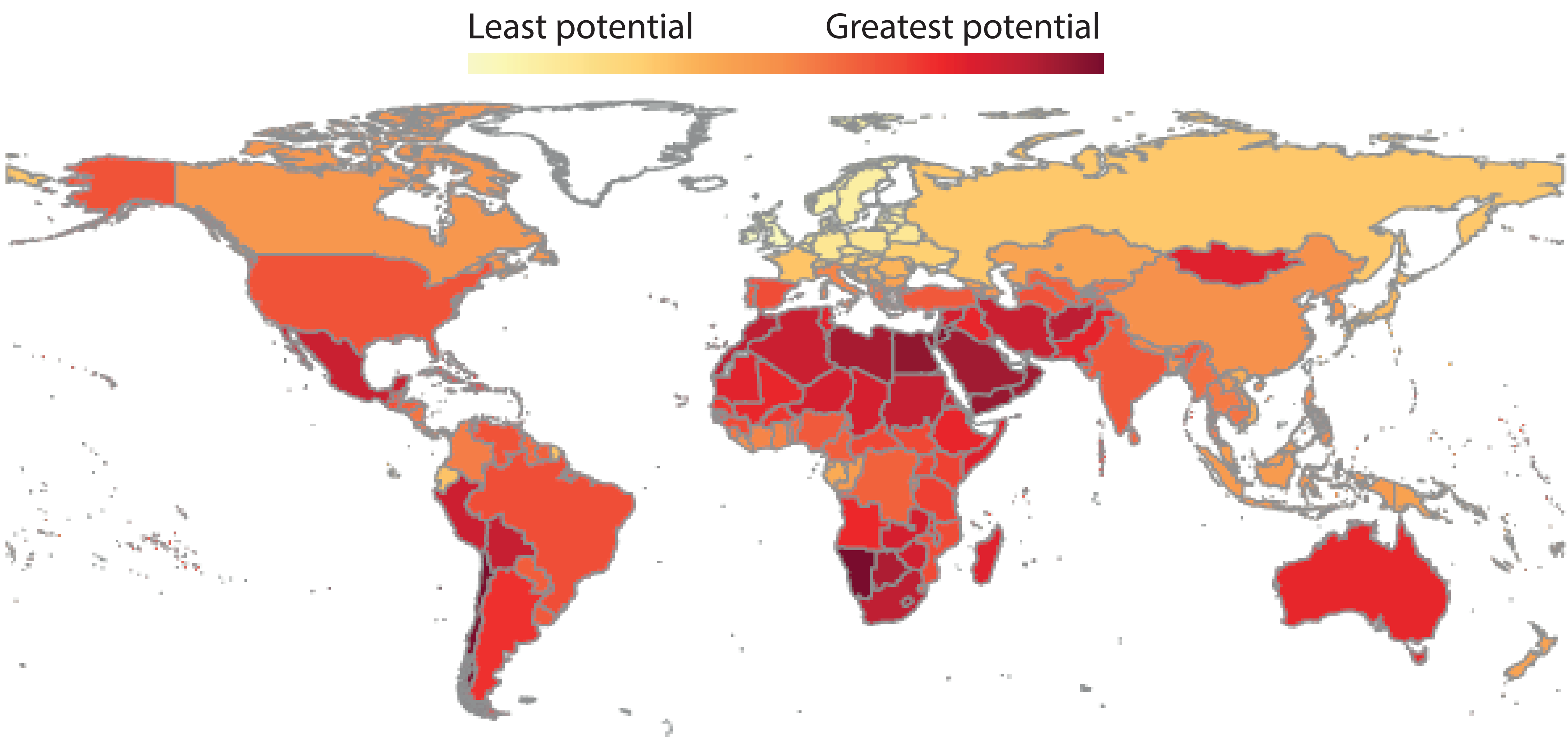
Nuclear projects are capital intensive and subject to long permitting procedures and, very often, significant construction delays. Political and societal resistance to nuclear energy in several European countries further limits its deployment potential. Advanced nuclear reactors – including small modular reactors – promise to overcome these barriers, but it is unclear whether this promise will be delivered, as development of the technology is still at an early stage.

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

2.2 Importing energy-intensive inputs is cheaper than importing energy directly

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

Figure 2. Average practical solar PV potential (kWh/kW)



Note: we plot the variable average practical potential (PVOUT Level 1) from the dataset.
Source: Bruegel based on ESMAP (2020).

Figure 3 shows estimates of the costs of transporting one unit of energy via different clean and fossil-energy carriers. Liquid fuels are more expensive to transport because of fixed liquefication and regasification costs, which dominate overall costs. We compare these fossil and green energy costs to the implied costs of transporting green energy contained within reduced iron[6]. The implied cost is higher than for gas and oil via pipeline, but cheaper than green alternatives.

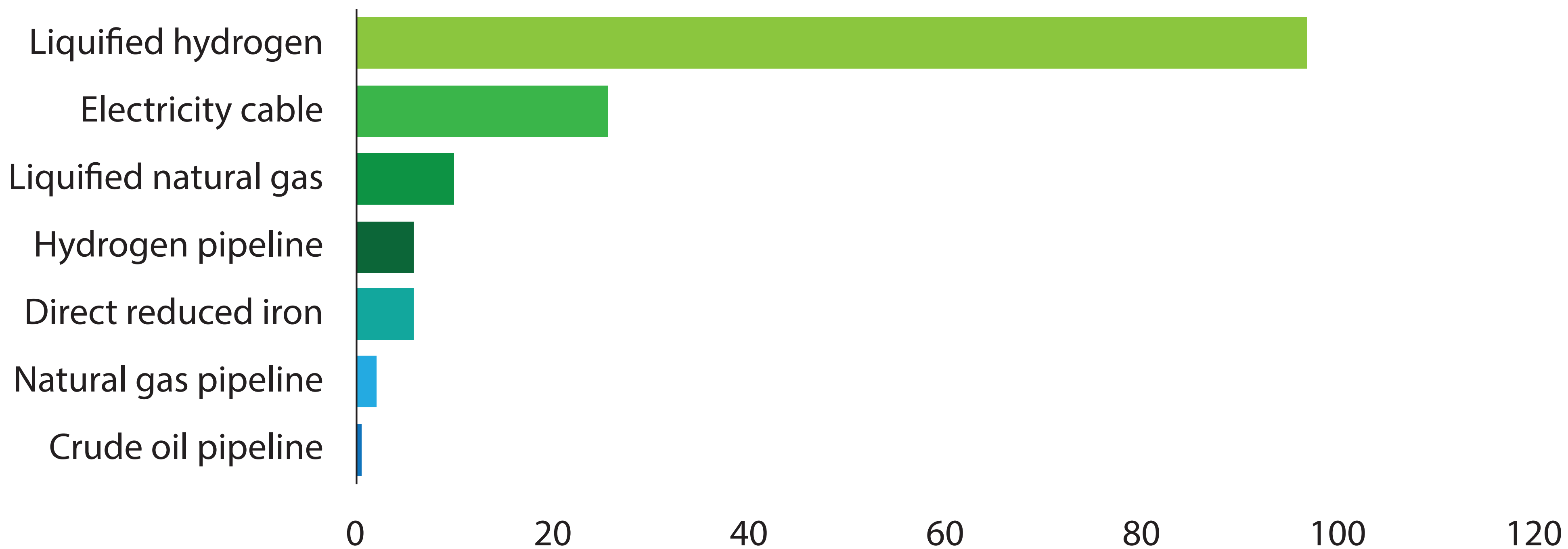
Therefore, the future global green energy system will likely be characterised by far less direct energy trade than currently. The present reality in Europe does little to dispel this notion. Only a small share of electricity is imported, while plans for hydrogen pipelines are long delayed.

Meanwhile, the uneven distribution of green energy endowments will create economic pressure for industrial relocation and trade in both final goods and intermediate inputs. This pressure will be particularly strong for commodities or products for which energy costs are a large share of total production costs (Samadi *et al* 2023).

Examples include ammonia and methanol (inputs into long value chains including fertilisers, synthetic fuels, olefins, resins and other high-value chemicals), and reduced iron, which can be transported by sea, much like iron ore is today, and accounts for approximately 70 percent to 80 percent of the energy consumption across the green primary steel value chain (Box 1).

At the same time, there is little relocation pressure beyond intermediate products because the energy demand for production of semi-finished products, such as flat steel products or plastic pellets, is low and transport costs are not reduced further compared to transporting intermediate products.

Figure 3. Stylised costs of transporting one MWh of energy over 1000km ($)



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

Box 1. Implications of energy cost differentials for trade in intermediate inputs

Steel offers a clear example of the potential for trade in green intermediate products. Traditional production of primary steel involves burning iron ore using coking coal, both of which are imported by European steelmakers. A potentially economically attractive decarbonisation pathway for the production of green steel is to instead reduce iron ore using hydrogen.

Reduced iron can then be transported by sea, much like iron ore today. Producing reduced iron would account for up to 80 percent of the energy consumption across the green primary steel value chain (Vogl *et al* 2018; Alikulov *et al* 2024). European steelmakers who want to green their production must thus choose between importing reduced iron or importing iron ore and importing or producing hydrogen.

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

For Germany, Egerer *et al* (2023a) evaluated the three sectors with the highest projected hydrogen demand: green iron for steelmaking, ammonia production and conversion into urea, and methanol production and processing into ethylene. For each value chain they assessed full domestic production, hydrogen imports to feed domestic value chains, imports of intermediate products for further processing, and imports of final products.

They found that energy costs will impact future green value chains and that relocation of some productive capacity to countries with excellent renewable energy conditions is likely. The effects are most striking for urea and ethylene, for which full German domestic production and hydrogen imports would be uncompetitive internationally – 15 percent to 25 percent more expensive than production abroad. Only by importing intermediate products does final urea and ethylene production in Germany become internationally competitive.

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

Green steel value chains are only just emerging and hence empirical evidence on relocations is lacking. However, ArcelorMittal has expressed interest in importing reduced iron to its European plants[7]. A survey of managers at the world's 50 largest steel and chemical companies found renewable energy potential to be the most important factor influencing locational investment decisions (Eicke and Quitzow 2025).

2.3 Economic costs for the EU

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

Direct impact on value added and employment

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

'Cascading' deindustrialisation?

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

If transport costs for a set of tradeable energy-intensive products are low compared to agglomeration advantages, factors including skilled labour availability and proximity to demand play more important roles in the locational decisions of any later or associated value chain stages. This is the case for most current industrial processes, which locate largely independently of fossil-fuel or mineral reserves.

For steel, the costs of transporting direct reduced iron are similar to the costs for transporting iron ore (Bilici *et al* 2024), suggesting there will not be major pressure for other iron and steelmaking processes to locate alongside DRI production. Germany's steel industry in the twentieth century grew close to locally sourced coal and iron.

As domestic coal production and iron ore extraction were phased out in favour of imports, locations have remained resilient (Egerer *et al* 2023a). For the chemical sector, ammonia – produced from natural gas – is already a widely traded intermediate product (Egerer *et al* 2023b).

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

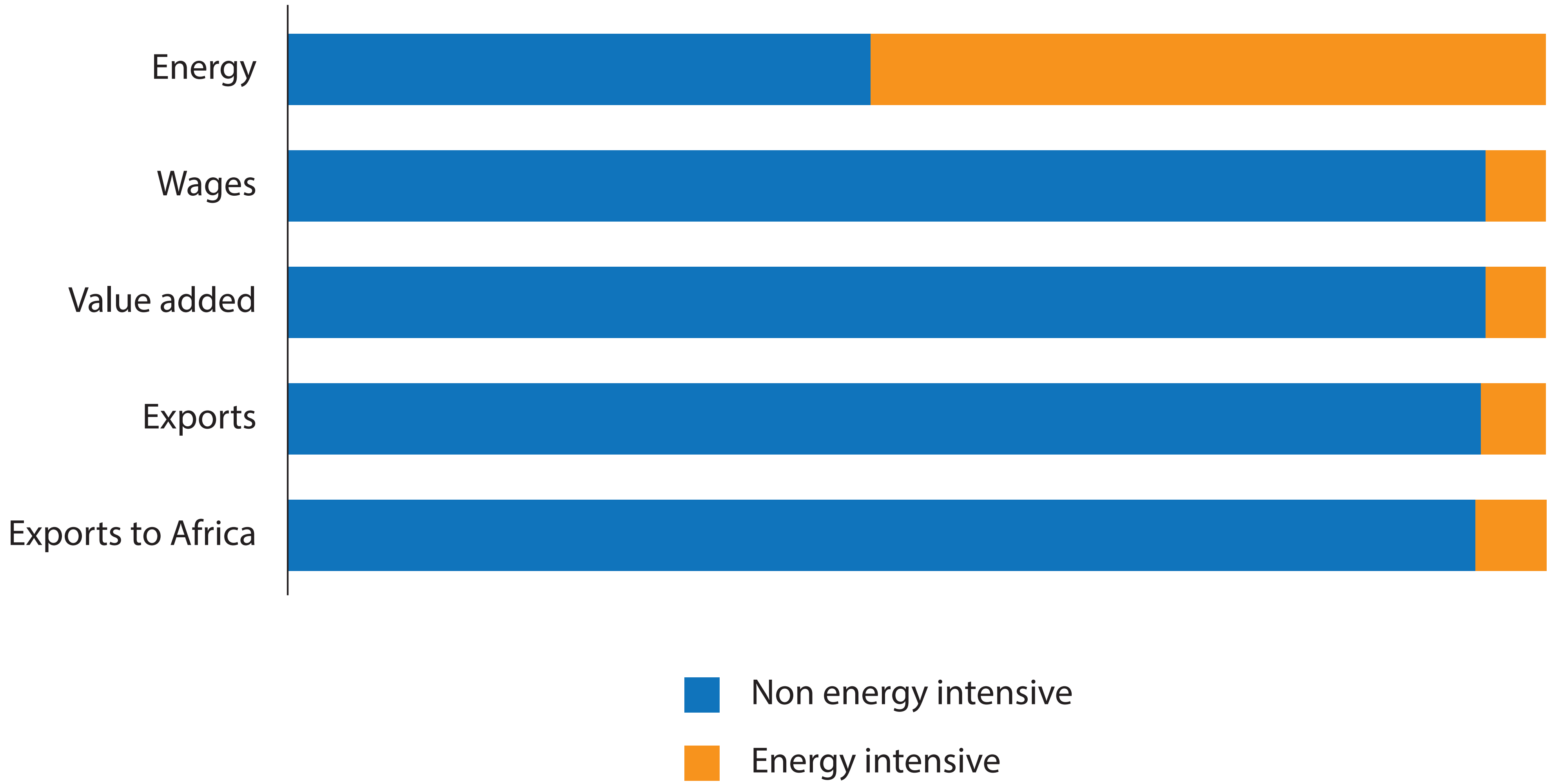
At the onset of the crisis, the aggregate economic impacts on the German economy were the subject of much debate. Estimates for the GDP impact from a full Russian gas cut-off varied wildly from a 2 percent to 12 percent loss (Moll 2024). Larger negative estimates were driven by the assumption that a reduction in output from one area of the economy would have substantial knock-on effects on other processes.

Fortunately, this did not happen. While production from energy-intensive industries fell by one-fifth, output from the rest remained broadly flat, despite inflationary pressures, geopolitical tensions and a large drop in European demand for automobiles (Figure 5).

Part of the reason is that firms shifted into higher value-added products and used fewer intermediate products. This led to a decoupling of industrial output (which fell) and manufacturing value-added in Germany, which remained steady (Fletcher *et al* 2024). Firms also increased imports of intermediate products (Fontagné *et al* 2023).

These imports helped replace outputs from domestic energy-intensive processes, which in turn helped maintain the production of final products (Chiacchio *et al* 2023). For fertiliser production in Germany, Stiewe *et al* (2022) found that growth in imports replaced domestic production of ammonia, keeping fertiliser production steady.

Figure 4. Distribution between intensive and non-energy-intensive industrial activities in Germany



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

2.4 Economic benefits for the EU

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

- **Direct benefits to EU downstream industries.** The relocation abroad of early-value-chain stages can have positive economic effects by lowering input costs for downstream industries in the importing country. This argument applies both to the downstream stages of energy-intensive production and to associated services. For example, the international division of solar PV value chains has facilitated a boom in solar service jobs in Europe and the United States[8].

- **Spillover benefits for other industrial sectors and consumers.** Bas and Strauss-Kahn (2014) investigated firm-level imports into France from 1996 to 2005, finding that imported inputs raised productivity and exports. New imported inputs have been shown to facilitate the introduction of new products in the EU (Colantone and Crinò 2011). In relation to imported energy-intensive products, the likely channel for beneficial spillovers will be electricity price cuts for other industrial consumers and for households, boosting competitiveness and making energy more affordable.

The magnitude of both effects will depend on the volume of energy embodied in imported intermediate inputs and its effect on prices. A rough estimate (see the appendix) suggests that imports of direct reduced iron, ammonia and methanol could reduce EU electricity demand by more than 500 TWh. This is more than one-quarter of today's green electricity production in the EU, and around one-tenth of 2050 projected demand. Trade in other products that undergo energy-intensive processes, such as polysilicon, refined minerals and aluminium, would increase the savings.

It is also conceivable that air and sea transportation will be decarbonised by the use of synthetic hydrocarbons: chemical fuels that replicate mineral fuels such as kerosene but are produced using electricity to combine hydrogen with captured carbon dioxide. Synthetic hydrocarbons might be considered a form of intermediate product, potentially adding another large chunk of tradeable embedded energy.

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

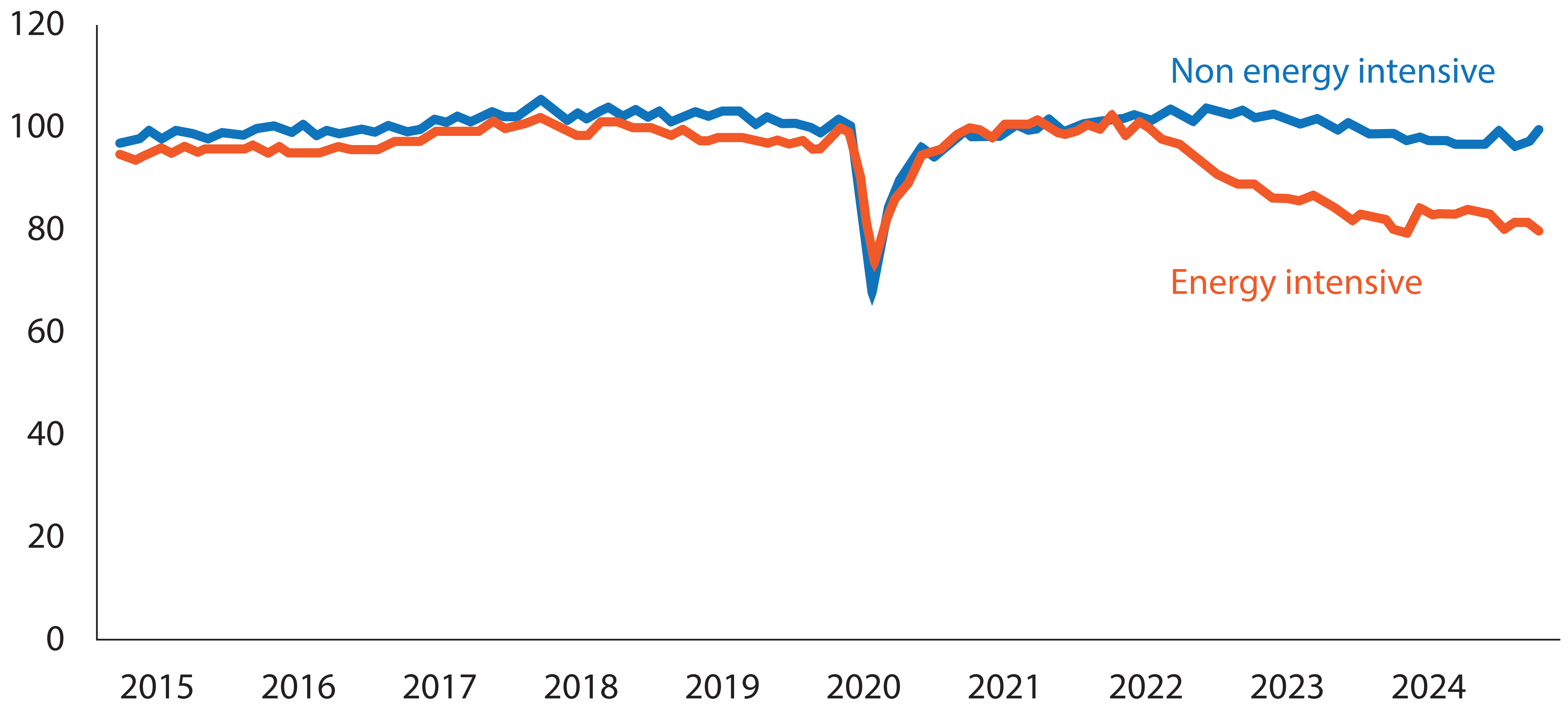
Importantly, maintaining some energy-intensive green energy demand in the EU can have a positive system effect to the extent that it is flexible and can load-shift to follow swings in supply. Large point sources of electricity demand, which can quickly ramp their consumption up and down, can act almost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

2.5 Economic security

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

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

Figure 5. Indexed EU industrial output, energy-intensive and non-energy-intensive sectors



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

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

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

3 The view from outside: consistency with the industrialisation of the Global South

3.1 Economic benefits for the Global South

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

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

Exports of intermediate products will create jobs and value added. For instance, exporting green reduced iron can raise local employment by 16 percent per tonne of DRI produced in Global South countries compared to exporting the equivalent volumes of green hydrogen and iron ore separately (Agora Industry 2024).

Meanwhile, countries in the Global North would retain more than 90 percent of existing jobs in the steel value chain, and the final production cost of steel would be reduced by 16 percent. Caiafa *et al* (2025) investigated the Brazilian state of Ceará, from where liquid hydrogen or green steel might be exported to the Netherlands. Performing the additional step of green steel production in Ceará could increase local value added (+3 percent), incomes (up to 23 percent) and employment (up to 35 percent) (Caiafa *et al* 2025).

The desire to onshore additional value chain steps is a clearly stated policy goal for countries of the Global South. Chile is generally considered to have avoided the natural resource curse and been able to translate large resources of copper and lithium into economic growth through industrialisation strategies (Gutierrez *et al* 2022).

The Indonesian government plans an integrated battery value chain in order to leverage upstream domestic nickel resources that were previously exported[9]. Meanwhile, the Democratic Republic of Congo has reviewed agreements with Chinese mining firms that were deemed exploitive and now seeks partnerships with other investors[10].

Closer to Europe, plans for green-iron production are materialising in North Africa – in Mauritania, for example, where green iron will be produced alongside green hydrogen (Karkare and Medinilla 2024). ArcelorMittal is exploring green hydrogen, iron and steel production in Mauritania[11]. In Egypt, Italian group Danieli has submitted a proposal to the government to build a green-steel plant to exports to the EU[12], while the German SMS group plans a 2.5 million tonnes green-iron facility in the Suez Canal Economic Zone, investing $1.06 billion (Karkare and Medinilla, 2024).

3.2 Global climate benefits

An EU green industrialisation strategy that only stimulates the production of enough green energy for domestic consumption is neither sufficient nor desirable. Establishing early value chains abroad is important for global green industrialisation. Large emission reductions can be driven by countries that specialise in line with their environmental comparative advantages. Modelling the impacts of a carbon tax, Le Moigne *et al* (2024) found that just over one-third of global emissions reductions could come from trade-enabled reallocation.

The creation of early green industrial value chains abroad can develop green knowhow and reduce the costs of developing full green value chains abroad. For example, the availability of cheap green iron is the crucial determinant of cost-effective green steel production, and the construction of a first green iron plant (perhaps for export) can reduce the costs of constructing a second (perhaps for domestic consumption).

Green industrial transformation in Europe and green industrialisation in the developing countries can reinforce each other. Huge growth in green industrial product manufacturing is needed, and critical for meeting global climate targets. The EU accounts for less than 10 percent of global industrial emissions and much future industrialisation will occur in the Global South[13].

In particular, developing countries lack scrap steel and are forecast to become increasingly dependent on the production of crude steel (Watari *et al* 2023), which will be emissions-intensive unless the greening of this production takes place, supported by integration in global value chains. While controversial from an economic-security standpoint, the global climate benefits of China leading in the energy-intensive production of solar panels and batteries from the early 2000s have been enormous.

4 Implications for EU economic policy

To reconcile its clean industrialisation objectives with those of the Global South in a cost efficient and politically viable manner, the EU needs to adapt its domestic and foreign economic policies.

4.1 Domestic economic policy: smarter industrial policy for energy-intensive sectors

One of the toughest industrial policy questions facing Europe is how to handle energy-intensive industries (EIIs). Should Europe do whatever it takes to retain them all – for reasons spanning from jobs to economic security? Should they be retained on condition that they decarbonise in line with European Green Deal targets?

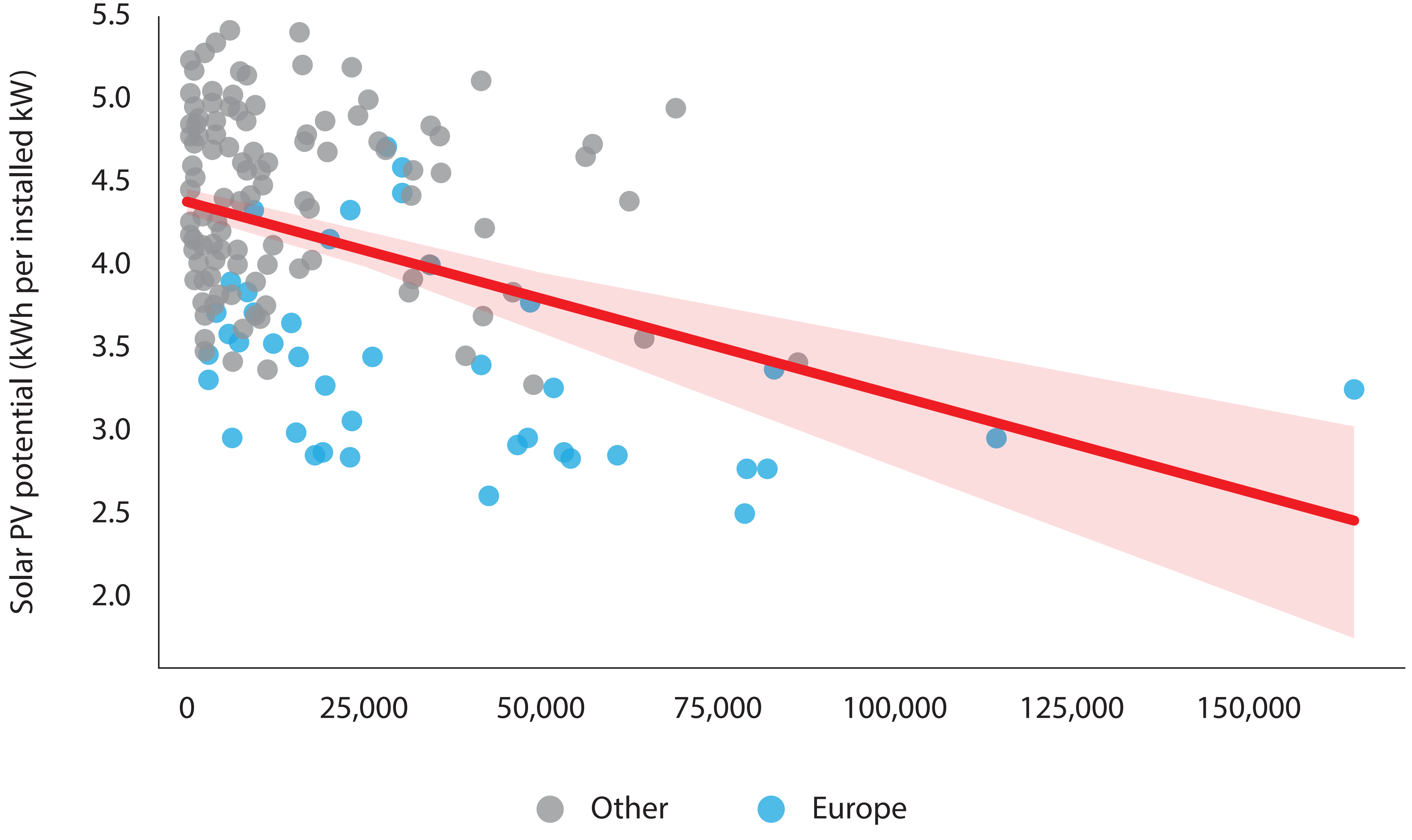
Or should a more selective approach be taken that offers public support only to those EIIs and/or energy-intensive production stages that both embark on a green transformation and are likely to remain competitive, even if energy prices remain higher in Europe than elsewhere?

European governments, with the tolerance of EU state aid rules, have so far largely opted for the first option: subsidising EIIs unconditionally. Energy subsidies are the clearest illustration. On average across Europe, EIIs pay 50 percent less per unit of electricity consumed than households, and in many countries the gap is even larger (Heussaff *et al* 2025).

Such differences arise because EIIs can sometimes access better rates from suppliers because of their scale, but also because they often pay lower network costs than households and frequently don't pay certain cost components, such as the costs of public support for new renewable projects.

The second option – maximum effort to retain EIIs provided they decarbonise – was advocated by Draghi (2024), who called for EIIs to be given preferential access to special low-cost electricity generation portfolios, publicly procured liquified natural gas and further electricity network tariff rebates.

Figure 6. Practical solar PV potential vs GDP per capita



Note: see Figure 2 for solar PV potential (average practical potential, PVOUT Level 1).
Source: Bruegel based on ESMAP (2020).

To prevent single market fragmentation triggered by national subsidies, and to ensure efficient distribution of activities across the EU in line with comparative advantage, Draghi (2024) also called for a prominent EU-level component in decarbonisation funding for EIIs, similar to the EU Innovation Fund's 'Hydrogen Bank,' and including reformed and expanded Important Projects of Common European Interest (IPCEIs)[14].

The EU Clean Industrial Deal plan (European Commission, 2025a) adopted a version of Draghi's recommendations. It proposes substantial EU-level instruments to fund EII decarbonisation, starting with a €100 billion EU Industrial Decarbonisation Bank to be created alongside the Innovation Fund.

But it also proposes a friendlier approach to national state aid than Draghi (2024), calling for a new Clean Industrial State Aid Framework that would facilitate national support for EIIs and clean-tech manufacturing, replacing the Temporary Crisis and Transition Framework – Commission criteria for approving state aid *"to foster support measures in sectors which are key for the transition to a net zero"*, adopted in March 2023 in response to clean-tech subsidies in the United States[15].

The second option would be far better than the first. Unlike the first option, it is consistent with Europe's net zero goals. But it remains problematic from the point of view of European competitiveness and from a global perspective.

From a European perspective, the approaches of Draghi (2024) and the Clean Industrial Deal create a distributional problem that could reduce growth and competitiveness. Subsidising electricity consumed by EIIs implies higher costs for other electricity consumers and possibly taxpayers. For example, reducing electricity prices for EIIs to 2019 levels by shifting system costs among consumers would increase household electricity prices by about 15 percent (Heussaff *et al* 2025).

Likewise, removing value-added tax from electricity consumed by EIIs would create significant shortfall in national budgets, as tax revenues from VAT on electricity amount to tens of billions of euros each year in the EU. Preferential treatment of one category of energy consumer thus inevitably raises issues of fairness and efficiency.

It makes no sense for Europe to provide scarce energy at a discount to sectors that provide less value added per unit of energy, rather than allowing less energy-intensive sectors with higher growth potential to flourish.

From a global perspective, the approach is problematic because it ignores the potential for greater gains from global trade and comparative advantage in a decarbonised global economy. Subsidising European EIIs encourages the continuation of high-cost production in Europe, instead of allowing market forces to direct energy-intensive manufacturing to those regions that, thanks to their renewable energy endowments, are best suited for such production.

This raises the global cost of decarbonisation. It may also undermine international climate cooperation if developing countries with ample renewable energy endowments become frustrated with the unwillingness of advanced countries to integrate them into green supply chains.

Europe should be more selective when supporting EIIs. Industrial subsidies should depend on two main criteria: the greening of EIIs – an essential step to ensure their long-term international competitiveness in a decarbonising global economy – and the efficiency of production in Europe post-abatement, conditional on realistic assumptions about European energy costs.

The latter hinges on two sub-criteria: i) energy intensity: how much energy the decarbonised process still requires, and whether this aligns with Europe's future green energy availability and cost; and ii) cost-effectiveness in a global context: whether similar emissions reductions could be achieved more efficiently by supporting abatement in the Global South, where decarbonisation costs may be lower.

To apply this approach, two main channels through which EIIs are currently subsidised should be distinguished:

1. Allocation of free allowances under the EU emissions trading system (ETS). From 2026 to 2034 approximately 2.8 billion ETS allowances will be allocated for free – a financial envelope of some €200 billion at current prices. As the point of free allowances is to prevent carbon leakage (relocation of carbon-intensive industry beyond the reaches of the ETS) before the EU carbon border adjustment mechanism (CBAM) enters fully into force, it is fine to allocate them only based on emission reductions, ignoring the energy-intensity of production.

2. Second, direct subsidisation of capital expenditure or production, including energy subsidies. In these cases, it is not acceptable to make subsidies conditional only on abatement. In addition, no subsidies should be provided to highly energy-intensive stages that it would be more efficient to offshore (with the exception of a minimum capacity that might be justified on security grounds).

This approach would allow Europe to maximise the impact of public funds, support industries for which competitive green production is viable and contribute cost-effectively to global decarbonisation.

4.2 Foreign economic policy: supporting green industrialisation in the Global South

To support both global decarbonisation and the competitiveness of European production, selective domestic subsidies need to be complemented by a strong foreign economic policy that supports the development of manufacturing capabilities for energy-intensive intermediate products in Global South countries that are rich in both raw materials and renewable energy endowments, and integrates these products into Europe's green supply chains.

The European Commission has proposed Clean Trade and Investment Partnerships (CTIPs; European Commission 2025a, section 6.1). While detail and a framework are lacking at time of writing (some detail has been offered on the first CTIP being prepared with South Africa), this initiative is potentially important.

Through CTIPs, the EU could engage with third countries more coherently than currently. The EU already runs several initiatives in parallel – including Energy Partnerships, Green Partnerships, Critical Raw Materials Strategic Partnerships and the Global Gateway – but these are often in silos. This prevents an integrated approach covering the whole green product supply chain and makes EU climate and industrial diplomacy less efficient.

To be credible, CTIPs should be structured not only as trade diplomacy platforms, but as practical toolkits including both supply- and demand-side instruments to mobilise private-sector investment in green value chains.

On the supply side, blended finance instruments should be deployed, including those already available through the Global Gateway, new resources under the next EU budget (2028-2034) and from the European Investment Bank. This will reduce investment risk and crowd-in private capital.

Technical cooperation on setting and harmonising green standards is also required, particularly for emerging sectors such as green steel, green cement and green chemicals, for which early alignment can shape global norms. Support for local green industrial ecosystems is essential. This could take the form of joint industrial clusters, similar to efforts in Namibia, where European and local firms collaborate to build integrated, low-carbon value chains[16].

Replicating and scaling-up such initiatives elsewhere – especially in countries rich in renewable energy and critical raw materials – would help embed industrial value creation locally, promote technology transfer and ensure that green value chains deliver inclusive growth and environmental benefits.

On the demand side, the credibility and success of CTIPs will depend on Europe's ability to offer stable and attractive long-term market signals. Guaranteed offtake agreements for the intermediate green products produced in the Global South under CTIPs should be supported, for instance by allowing them to qualify under sustainability and resilience criteria[17] in the EU Net-Zero Industry Act (Regulation (EU) 2024/1735). Expanding the geographical scope of such criteria to include CTIP partner countries could greatly enhance the cost-efficiency and the effectiveness of the measure.

The EU could also promote joint offtake pools or demand-aggregation platforms, similar to H2Global, a German scheme to support investment in renewable hydrogen production in non-EU countries, which will be then imported and sold in the EU. The H2Global scheme works as a double auction model, with the German government providing a subsidy to the most competitive bids for exporting green hydrogen (or derivatives such as ammonia) into Germany.

A broader range of green projects in third countries could also be fostered under the EU Innovation Fund – as is being done for hydrogen. By supporting green intermediate products outside the EU and linking them to guaranteed demand in Europe, such mechanisms would help anchor investment decisions in partner countries and deepen industrial cooperation along clean value chains.

By integrating these demand-side tools, CTIPs can help bridge the commercialisation gap, making green industrialisation projects in partner countries bankable and scalable, while reinforcing the EU's own industrial resilience and climate leadership. ■

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Appendix: a rough estimate of European intermediate product green energy demand

We estimate the green energy demand required to produce three intermediate products in Europe: direct reduced iron as an input to the steel value chain, and ammonia and methanol as intermediate products for chemicals value chains (see for example Egerer *et al* 2023a).

We start with current demand for each product in the EU and estimate the volume of green energy that would be required to produce a similar volume of green products. For steel and ammonia, we assume constant demand; for methanol we assume an increase in demand because there is significant potential for methanol to replace some current hydrocarbon uses.

In 2023, the EU produced 126 million tonnes of crude steel (Eurofer 2024), via two production routes: blast oxygen furnaces and electric arc furnaces. An electric arc furnace consumes electricity and overall emissions can largely be removed through the use of green electricity. Therefore, steel decarbonisation through hydrogen aims to replace supply from blast oxygen furnaces.

We calculate the hydrogen required to provide enough direct reduced iron to replace current EU blast oxygen furnace production of 70 million tonnes of steel annually (Eurofer 2024).

Producing one tonne of direct reduced iron requires 60 kilogrammes of hydrogen (Egerer *et al* 2023a). One kilo of hydrogen is equivalent to 33 kWh energy. Therefore, the required hydrogen energy demand to produce 70 million tonnes of direct reduced iron is 140 TWh.

For ammonia, EU demand is 19 million tonnes with 17 million tonnes produced domestically, and net imports of 2 million tonnes (Kneebone and Piebalgs, 2023). We calculate the hydrogen required to replace all this demand domestically. The requirement to produce one tonne of ammonia is estimated at 197 kilos of hydrogen, or approximately 6,500 kWh of hydrogen energy. Total demand is therefore estimated at 125 TWh.

Current EU demand for methanol is a little under 10 million tonnes. Renewable methanol demand could replace conventional fossil methanol demand, but potentially also certain hydrocarbon uses – synthetic hydrocarbons can be produced using methanol as a base.

Methanol demand in the EU might therefore grow to 18 million tonnes by 2030 (Kneebone and Piebalgs, 2023). Producing one tonne of methanol requires 210 kilos of hydrogen (Egerer *et al* 2023a), equivalent to 7,000 kWh hydrogen energy. This implies total demand of 125 TWh of hydrogen.

For the EU to produce sufficient quantities of the three intermediate products, 390 TWh of hydrogen may therefore be required in total. There is considerable uncertainty about future demand and technologies and so this number is only illustrative of the potential. Producing this hydrogen domestically would require a little over 550 TWh of green electricity production, assuming an electrolyser operating at 70 percent efficiency.

Endnotes

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

2. See European Commission, 'Clean Industrial Deal', undated.

3. See 'Affordable Energy'.

4. 2,000 TWh out of a total 3,300 TWh demand across energy and non-energy uses.

5. Bruegel calculations based on the Ember electricity dashboard.

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

7. Rachel Parkes, 'Green hydrogen is too expensive to use in our EU steel mills, even though we've secured billions in subsidies', Hydrogen Insight, 21 February 2024.

8. See the Bruegel European Clean Tech Tracker.

9. Isabelle Huber, 'Indonesia's Battery Industrial Strategy', Commentary, 4 February 2022, CSIS.

10. Pesha Magid, 'Congo courts Saudi mining investors to help curb China dominance', Reuters, 14 January 2025.

11. See ArcelorMittal press release of 25 May 2022, 'ArcelorMittal signs MoU with SNIM to evaluate the opportunity to jointly develop a pelletisation plant and DRI production plant in Mauritania'.

12. Anna Vassileva, 'Egyptian govt weighs Danieli Group's plan for green steel complex', Renewables Now, 29 February 2024.

13. The industry sector in 2022 globally was responsible for 9.0 Gt CO_2 emissions; see IEA, 'Industry', undated; total emissions from manufacturing in the EU were 0.7 Gt in 2023 (Eurostat).

14. The Hydrogen Bank is a European financing initiative that supports clean hydrogen projects selected through competitive auctions. Consortia of hydrogen suppliers and off-takers bid for a subsidy necessary for their project to be realised. IPCEIs are cross-border projects through which European governments provide financial support to consortia in research, development and infrastructure for critical technologies such as microelectronics, batteries and hydrogen.

15. See European Commission, 'Temporary Crisis and Transition Framework'.

16. In November 2022, Namibia and the EU signed a memorandum of understanding for a strategic partnership in sustainable raw materials value chains and renewable hydrogen, with the goal of mobilising €1 billion in investment from the EU, EU countries and European financial institutions. See European Commission press release of 24 October 2023, 'Global Gateway: EU and Namibia agree on next steps of strategic partnership on sustainable raw materials and green hydrogen'.
17. These require public authorities to take into account non-price criteria for certain net zero technologies in procurement processes and in auctions for the deployment of renewable energy.

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The struggle against hesitation

The EU is engaged in a struggle for independence, values and democracy in a world shaped by the re-emergence of imperial ambitions. Simone Tagliapietra says Ursula von der Leyen is right to say Europe is in a ‘fight’ around competitiveness and values, but it may lack the right pugilistic attitude

European Commission President Ursula von der Leyen on 10 September 2025 gave her fifth state of the union speech to the European Parliament. Previously, she held out the promise of a 'geopolitical Commission', or a stronger Europe in the world, though for much of her tenure, this idea has remained more theory than practice. This year's speech, however, shifted notably in tone: she asked if Europe has the stomach for a fight.

Von der Leyen portrayed Europe as engaged in an unprecedented struggle for independence, values and democracy in a world shaped by the re-emergence of imperial ambitions. She had strong words about the wars in Gaza and Ukraine, and on domestic front she gave particular attention to pressing issues for citizens, including the housing crisis and the rising cost of living.

She is right that Europe is in a fight. But to prevail, words must be rapidly matched by tangible instruments and a strong political will, at both national and European Union levels, to use them. This is far from the case today.

EU governments remain hesitant to embrace deeper integration, and the European Parliament is more polarised than ever, even within the majority that supports the President. Von der Leyen herself, despite the bold framing, still often falls back on the lowest common denominator among EU countries, rather than pressing for a more decisive EU strategy.

Nowhere is this tension clearer than on competitiveness. Von der Leyen is right to say that Europe's independence depends on its ability to compete, and that the continent must invest massively in digital and clean technologies. She is equally right to call for Europe to be faster, smarter and more European. Yet the record so far is thin.

The Clean Industrial Deal competitiveness and decarbonisation plan, proposed in February 2025, serves as a prime example of this. Conceived as means of fostering clean-tech investment and slashing energy costs, it largely remains a concept. The Commission has produced compasses, communications and dialogues, but tangible impacts are so far minimal.

The notable exception has been the revision of state-aid guidelines to allow more national subsidies for clean-tech manufacturing and established, energy-intensive industries. But this can encourage fragmentation, risking subsidy races among member states without addressing structural weaknesses.

Europe's problem is not an absence of ideas. It is the gap between rhetoric and delivery

It is now time to push the Clean Industrial Deal into its implementation phase. An ideal place to start would be putting in place the promised Industrial Decarbonisation Bank, fostering lead markets for clean innovative technologies with a smarter use of public procurement, and developing much-needed clean trade and investment partnerships with selected third countries. These initiatives should move forward as quickly as possible.

Specific announcements made by President von der Leyen during her speech, such as a €1.8 billion pledge to support battery production in the EU, fall short of being game changers. Chinese manufacturer CATL, in a joint venture with Stellantis, is investing more than twice that sum in a single gigafactory in Spain. The collapse in late 2024 of publicly-backed Northvolt, once Europe's flagship battery start-up, illustrates that money alone is not enough.

Structural weaknesses persist: reliance on foreign inputs, the challenges of scaling up production and fierce Asian competition. Von der Leyen failed to address them when she avoided a pressing question: how should Europe handle the wave of Chinese investment in its electric-vehicle and battery supply chains?

Her proposal to add 'made in Europe' criteria in public procurement also raises concerns. It has a protectionist flavour and sits uneasily with Europe's continued talk of open trade. More fundamentally, it risks turning the Clean Industrial Deal into an attempted reshoring exercise, rather than a strategic framework that to build on Europe's comparative advantages while keeping the doors open to global trade open.

The same ambivalence runs through her energy message. Von der Leyen declared that Europe is on the path to energy independence. But this jars with the EU-US energy deal, under which the EU has committed to around €700 billion up to 2028 in American liquified natural gas (LNG), oil and nuclear fuel purchases.

The US already accounts for 55% of EU LNG imports; replacing Russian LNG entirely with American supplies, instead of with a more diversified portfolio, would push that figure close to 70%. This is far from the concept of independence, or at least of supply diversification, and risks exacerbating structural weaknesses, not solving them.

Europe's problem is not an absence of ideas. It is the gap between rhetoric and delivery. The EU has shown it can act decisively in emergencies, as with COVID-19 vaccines and the energy crisis triggered by Russia's invasion of Ukraine. But in normal times, it hesitates. This is the true danger Europe must fight against. ■

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Weathering the storm

It's a time of profound change – technological, geopolitical, environmental. Sarah Breeden shares some real world examples of how risks to price and financial stability from climate change are emerging now, and how they might grow going forward

Introduction

It's a time of profound change – technological, geopolitical, environmental. I plan to explore the theme of our changing climate and the role of the Bank of England in delivering stability through that.

I am also honoured to speak to the commercial property sector, which is undoubtedly a hugely important sector of the United Kingdom's economy. It provides the physical space for businesses to operate, innovate and generate jobs. It attracts significant amounts of foreign capital as it does so. And it directly employs over 1 million people.

But it is also a sector that has over the years seen significant cycles of boom and bust and contributed to many financial stability challenges, both in the United Kingdom and overseas (including in the US even very recently). Understanding the challenges facing the sector is a critical part of our financial stability mission, and we are hugely grateful to the industry for the open and constructive engagement that you all provide.

Central to that engagement is the Bank's commercial property forum (CPF). Such engagement has been crucial as recent years have not been quiet. Just in the last five years, the CPF has helped us to navigate the financial stability risks from a global pandemic and the transition to a higher interest rate environment, all against a backdrop of rising global uncertainty.

Today, the sector continues to face headwinds. The latest Bayes UK CRE lending *Report* shows that almost 70% of all outstanding debt (around £100 billion in total) is due for repayment by 2027. Around 10% of debt matured in 2024 with a small minority in default and the rest restructured or extended. Refinancing pressures will likely be felt more acutely in sectors such as office and retail given the post-pandemic shift to more remote working and the continuing shift from physical to online shopping. The transition to higher rates is far from over.

But reassuringly, compared to before the financial crisis, bank lending standards have been much more conservative, and our stress tests show that the UK banking system is resilient to very large falls in CRE prices. Other players matter too, of course.

Non-bank participation in the UK CRE sector has grown rapidly since the global financial crisis, adding welcome diversification to the supply of funding. But here I am mindful of vulnerabilities in the non-bank sector – most notably liquidity mismatches, leverage and valuation opacity – and the potential for increased risks that they bring (FSB 2025).

The risks posed by a changing climate matter for individual firms' safety and soundness, the resilience of the financial system as a whole and, through their impact on the macroeconomy, the outlook for inflation

But I do not wish to focus on those vulnerabilities. Instead, I want to focus on the challenges of a changing climate. That matters for the Bank of England given our statutory responsibilities for monetary and financial stability. And it matters for you too, as the commercial real estate sector has both a key role to play in helping navigate the climate transition and a set of risks to manage as we do so. These risks from a changing climate are not hypothetical or somewhere far off in the distance.

Last year was the warmest year on record, with annual average global temperatures exceeding 1.5°C above pre-industrial levels. The IPCC estimates that average global temperatures are now more than one degree higher than pre-industrial levels. They are set to rise at 0.2°C per decade, given past and ongoing greenhouse gas emissions[1].

And as average temperatures rise, so too does the risk of passing through 'tipping points' as ice sheets collapse and weather patterns change, causing large, accelerating and potentially irreversible impacts[2].

The rise in temperatures has already increased the frequency and intensity of extreme weather events both abroad and at home. In the UK, intense storm rainfall, like that seen in 2023-24 is now expected to occur once in every five years (compared to once in every 50 under a pre-industrial climate). Under a 2°C pathway, that rises to once in every three years.

The risks posed by this changing climate matter for individual firms' safety and soundness, the resilience of the financial system as a whole and, through their impact on the macroeconomy, the outlook for inflation.

These are real risks that could materialise, and in some cases already are materialising, within the time horizons that the Monetary Policy Committee (MPC), Financial Policy Committee (FPC) and Prudential Regulation Committee (PRC) care about.

Indeed, when I first started work on climate change at the Bank almost ten years ago, my challenge was to explain how it might be relevant to the core mandate of a central bank. I think the examples. I'll cover demonstrate clearly how that case has now been made.

Price stability

Let me begin by looking at how the physical effects of climate change impact inflation, starting with food. Severe weather events – droughts, floods and extreme temperatures – can significantly impact global agricultural prices. Those events have been occurring with increasing frequency and intensity in recent years.

Historical experience suggests that severe weather events can generate price increases of over 30% in global agricultural commodity prices (de Winne and Peersman 2021). As an economy that imports a high proportion of its food – around 40% – UK inflation is highly susceptible to such changes. Another study by Peersman (2022) showed that for a 1% unanticipated increase in globally traded food prices, euro area headline inflation rose by 0.1%. Our own work at the Bank of England shows broadly comparable results for the UK.

UK food prices are also affected by extreme weather events that take place at home. As we saw in 2023, excessive rainfall can have significant impacts on the supply of domestic agricultural products[3]. Beyond food production, weather events, such as extreme heat, also disrupt infrastructure, such as transport, that are critical to food supply chains[4].

The impact of severe weather events on inflation extends beyond the food sector. A Bank of England study using county-level data for England over the years 1998-2021, shows that flooding impacts output and prices across sectors – including those that feed into core inflation (Ficarra and Mari 2025). It finds that the impacts differ across sectors, with some presenting as a demand shock and some as a supply shock.

What matters for monetary policy is the impact of such events on aggregate inflation. While most studies find negative impacts on GDP from extreme physical events, the estimated impact on aggregate inflation is less clearcut.

As set out in work by the Network for Greening the Financial System (NGFS), severe weather events impact the economy through demand, supply, and financial channels, with the aggregate inflationary impact depending, in theory, on whether the demand or supply effects of the event dominate[5]. That is uncertain[6].

But as my colleague James Talbot has highlighted, there is a growing body of literature to suggest that supply effects dominate, meaning these events increasingly represent a trade-off inducing shock for monetary policy makers to deal with (Talbot 2025).

These impacts are likely to increase over time as temperatures rise further and shocks become more frequent and severe. In a study for the ECB, Kotz *et al* (2023) show that without adaptation measures, global food price inflation might increase by 1-3pp by 2035, increasing pressures on headline inflation by between 0.3-1.2 pp.

They provide evidence that upward pressure from warmer temperatures on inflation is larger in warmer months and warmer countries, suggesting that the effects associated with climate change may be more pronounced as average temperatures rise.

More broadly, the emerging literature between climate change and inflation suggests a non-linear relationship (NGFS 2024). The possible existence of 'tipping points' adds to the importance of this work. In addition to considering these impacts on inflation from the physical effects of climate change, we need also to consider transition effects.

The UK government has for some time been implementing policies to transition to a less carbon-intensive economy, consistent with its commitment to reach net zero emissions by 2050. By reducing the physical effects of climate change, these actions will likely reduce the trade-offs monetary policy makers face in the long term. But they can have an impact on inflation in the shorter term. Indeed, I first discussed the role of carbon pricing in explaining some of the large rise and fall in inflation over 2021-23 in a speech I gave in January.

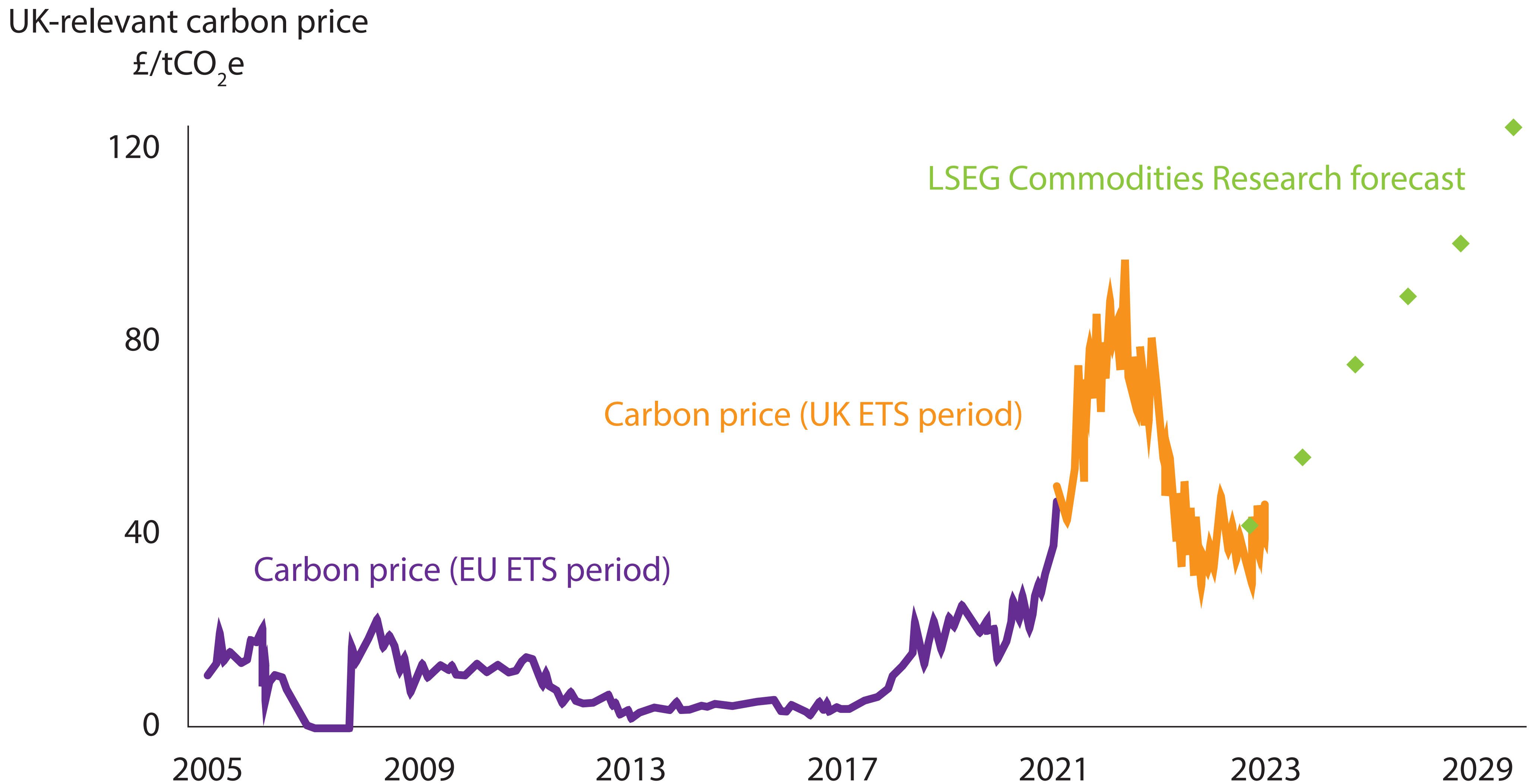
At its peak in October 2022, headline inflation reached 11.1% (ONS 2022), around 40% of which can be attributed directly to rising energy prices, especially gas and electricity. Russia's invasion of Ukraine and the resulting disruptions to gas supply – a classic 'gas supply shock' – forms the prevailing narrative for the initial rise in inflation (Alessandri and Gazzani 2025).

But while the invasion was undoubtedly the most significant single driver, carbon prices also rose rapidly during this period. By the summer of 2022, the UK Emissions Trading Scheme (ETS) carbon price had roughly doubled relative to the previous year (Chart 1), in part reflecting several policy announcements that effectively tightened the (future) supply of carbon allowances in both the UK and EU[7]. The rise in wholesale gas prices will have also contributed to the increase in carbon prices (Shin and Mari 2025).

We estimate that around 1 percentage point of both the increase and subsequent fall in headline inflation over the 2021-23 period is likely to have originated from these changes to carbon policy (Chart 2, RHS). That reminds us that changes in carbon policies can have both inflationary and disinflationary impacts. Indeed, looking over a longer horizon, changes in carbon policies have both pushed up and down on prices, albeit at much smaller magnitudes than in recent years (Chart 2, LHS).

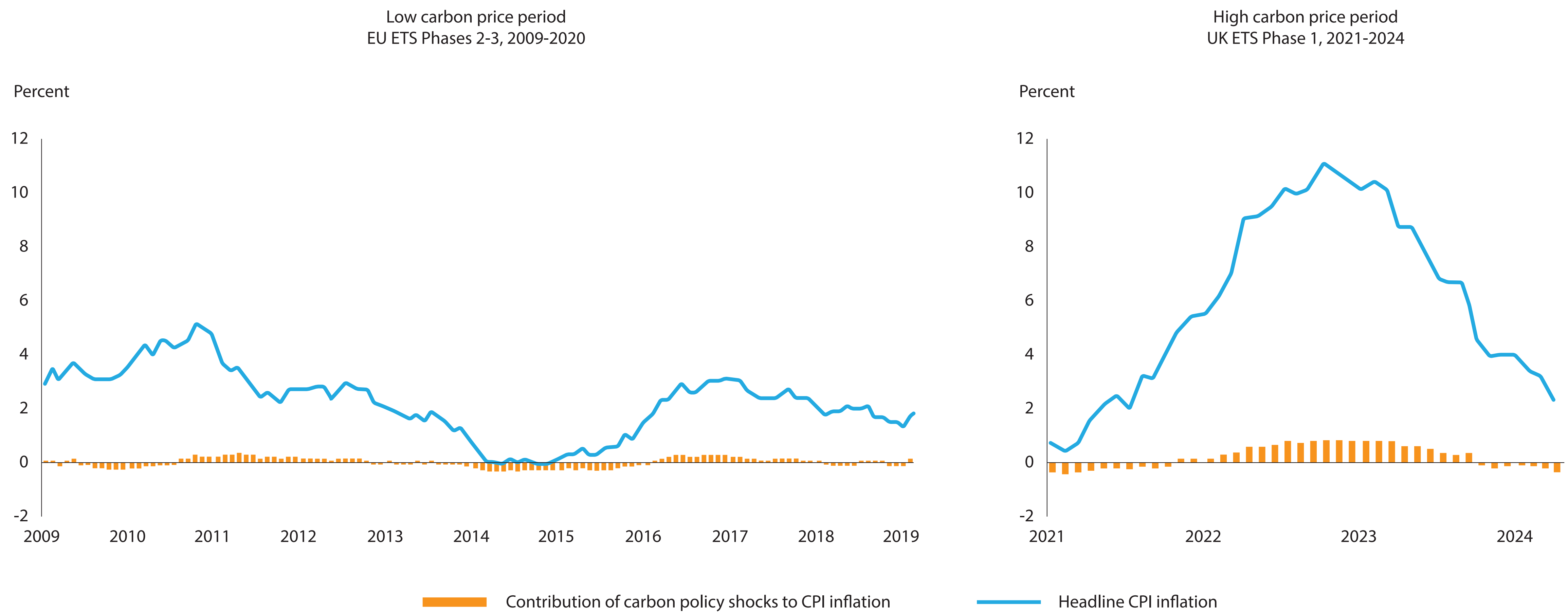
The energy sector plays an important role in the transmission of carbon policy shocks to inflation (Copeland *et al* 2025). Our estimates suggest that multiple energy-related commodity prices – including carbon allowances, crude

Chart 1. Carbon emissions allowance prices in the United Kingdom



Notes: The chart depicts the daily UK-relevant carbon price ie. the EU ETS carbon price from 2005-2020, and the UK ETS carbon price from 2021-24. The EU ETS price has been converted from EUR to GBP. The London Stock Exchange Group (LSEG) UKA forecast (green dots) is in normal terms (adjusted for 2% inflation).
Sources: Bank calculations. Data from LSEG and LSEG Commodities Research.

Chart 2. Historical decomposition of past contribution of carbon policy shocks to developments in UK headline inflation



Notes: The figure reports the historical contribution of the identified UK-relevant policy shock to UK headline inflation as estimated by the VAR model in Copeland et al (2025). To provide conservative estimates, the left-hand side chart is estimated using a 'low carbon price' sample period (June 2008 to December 2020) whereas the right-hand side chart is estimated using the full sample, which includes the 'higher carbon price', period (June 2008 to April 2024).
Source: Bank staff analysis based on Copeland et al (2025).

oil, and natural gas prices – increase in response to a shock. These rising costs are passed on to the energy prices faced by households and firms. And, via supply chains, energy intensive firms also pass these through to non-energy prices.

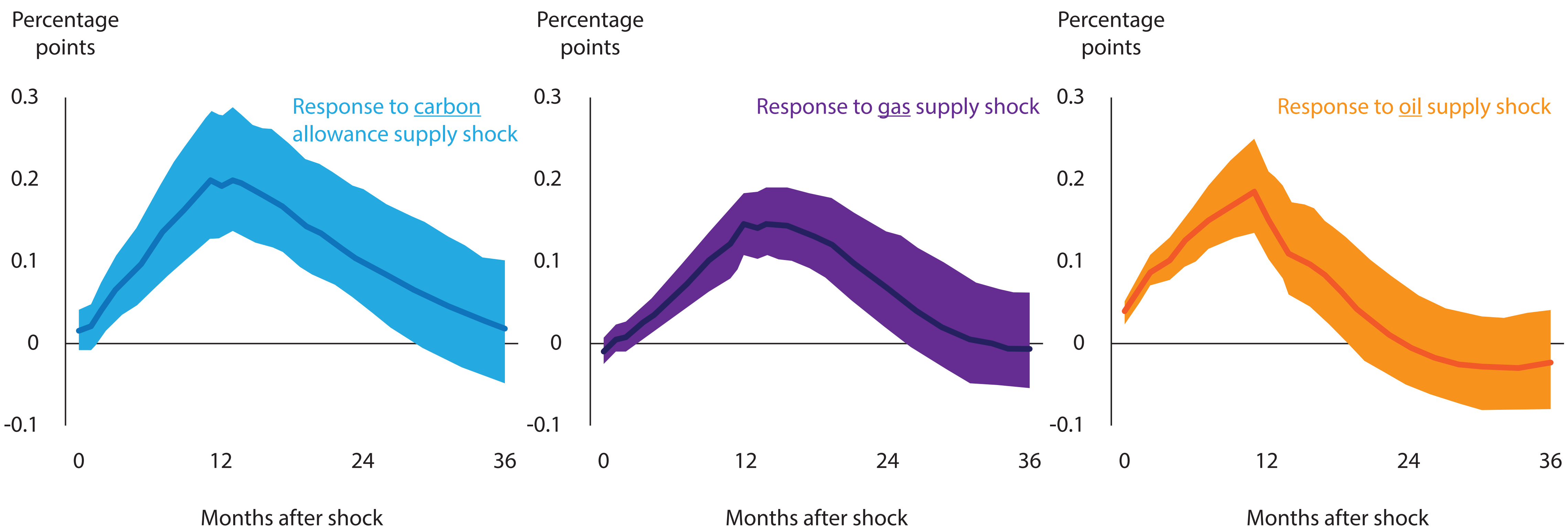
The source of an energy price shock matters for monetary policy. We have estimated that a 1pp rise in energy price inflation originating from a shock in the carbon market has a roughly 25% larger impact on headline inflation relative to an equivalent shock arising in the gas market. It is also several months more persistent than if it had originated in the oil market (Chart 3).

Oil and gas prices have historically been, and are likely to remain, the primary drivers of energy prices: it takes an unusually large carbon supply shock to generate a 1pp rise in energy price inflation[8]. But carbon shocks are likely to grow in frequency and size over coming years, as carbon pricing schemes become more stringent, sectoral coverage widens, and as carbon prices are expected to rise (diamonds on Chart 1). It is however also likely that the drive to decarbonise, particularly in the power sector, will reduce the aggregate impact of carbon price shocks over the longer term.

Understanding how these physical and transition risks transmit to inflation will be especially important for monetary policy makers. That's because, as these examples show, climate shocks have a significant effect on energy and food prices. These items are bought regularly and have particular salience for households, meaning they have outsized effects on inflation expectations (Bonciani *et al* 2024) and so potentially wage and price setting behaviour. In addition, in a world where these shocks become larger, more frequent and more persistent, the risks of these second-round effects become even greater.

Indeed, as my colleague James Talbot recently set out (Talbot 2025), these shocks sound rather similar to the shocks monetary policy makers have faced in recent years – large, unpredictable, but persistent supply shocks in areas of

Chart 3. Impulse response functions of UK headline inflation to carbon allowances, gas and oil supply shocks scaled to increase energy inflation by 1 percentage point at peak



Notes: Impulse responses to the identified UK-relevant carbon policy shock, and the natural gas and oil supply shocks identified by Alessandri and Gazzani (2025) and Känzig (2021). Responses are normalised to increase energy CPI inflation by 1 percentage point at peak. Estimation sample: June 2008 to April 2024 for the carbon and oil shocks, and to December 2023 for gas shock (owing to the shock series length). Note: our UK-specific reconstruction of Alessandri and Gazzani's gas shocks (which takes the UK NBP natural gas price change around event days) enables estimation over the full sample and yields similar results. The solid line represents the median draw. The shaded areas are the 80 percent credible intervals. For comparability across shocks, these are standardised to increase energy price inflation by 1 percentage point (at peak), which is a common scaling choice in the literature for ease of interpretation (see, for example, Känzig (2025) and Ortubai et al (2025)). It is worth noting, however, that this scaling choice means we are considering a particularly large shock in the carbon market: roughly 15 times bigger than a 'typical' (1 standard deviation) shock over the sample period.
Source: Copeland et al (2025).

salience for households. So monetary policymakers will need to understand the economic impact of these climate shocks and be ready to react as needed, if we are to keep inflation expectations anchored and inflation low.

With climate change already influencing the economy, a better understanding of how monetary policy might need to respond to climate shocks matters for investors too, including those in CRE. Building our collective understanding of what is happening and the appropriate policy response is not an easy task. But it is one we must rise to.

Financial stability

Climate change also matters for financial stability. Back in 2022 our Climate Exploratory Scenario explored the financial risks posed by climate change for the largest UK banks and insurers.

The exercise concluded that climate change creates risks to households and businesses globally, and so for the financial system. It showed that if banks and insurers did not respond effectively, climate risks could cause a persistent, material drag on their profitability. Loss projections varied across participant type and climate scenario, but amounted to hundreds of billions of pounds.

And losses would be significantly higher in a scenario with a late or disorderly transition and higher still in a scenario with no further policy action and so higher, and still rising, physical risks. Individual firms, and the financial system overall, would be much less resilient.

In that context, I'd like to hone in on two specific examples where climate risks becoming more proximate could directly impact financial stability. The first relates to a question that I – and other Bank colleagues – have raised of a possible 'climate Minsky moment', where the crystallisation of climate risk triggers broad asset repricing, perhaps similar to the impacts on asset prices we saw during COVID 19 or the start of the war in Ukraine[9].

The impact on repricing of any 'trigger climate event' would of course depend on the source of the shock, how well climate risks are priced before it, the speed of any repricing, and if vulnerabilities in market-based finance further amplify it.

Analysis of these risks has to be global. The UK has already made much progress in its transition to net zero. It has also experienced fewer extreme weather events than other parts of the world. But as a small, open economy with a large financial centre, the UK is exposed to crossborder spillovers in global financial markets, and the global operations of large UK companies and UK-based Non-Bank Financial Institutions (NBFIs) mean they are of course vulnerable to climate developments overseas.

On pricing, there is evidence that climate risk is starting to be priced in assets such as corporate and sovereign bonds. But our analysis suggests that current prices neither fully account for the transition risks we could see as part of the transition, nor the physical risks we could see in its absence[10].

In this context, markets over time or in response to a significant climate event begin to place more weight on scenarios where climate risks result in a broad- based macro shock, characterised by inflationary shocks, sharp changes in interest rates, and increased risk premia. And that would of course mean that they re-evaluate upwards their pricing of climate risk today.

The speed of repricing is crucial for understanding financial stability impacts. Rapid repricing could occur if markets start pricing in severe physical climate risks or a disorderly transition, perhaps following acute physical disasters. Even gradual repricing could result in short bouts of rapid price movements.

This repricing could affect a wide range of assets. Scenario analysis undertaken by Bank staff suggests that a portfolio of long-duration G7 sovereign bonds could lose 10-20% of its value given interest rate risk and increasing risk premia (depending on the scenario)[11]. Corporate credit spreads could widen, making the repricing of corporate asset classes even more significant.

Large UK NBFIs, which are more exposed to market risks like these than banks, might not be resilient to such a shock. The first-order repricing shock is of a similar size to the shock in last year's SWES[12]. Larger declines in sovereign bond prices could lead to uncertain behavioural responses by NBFIs, such as forced selling in excess of that observed in that exercise.

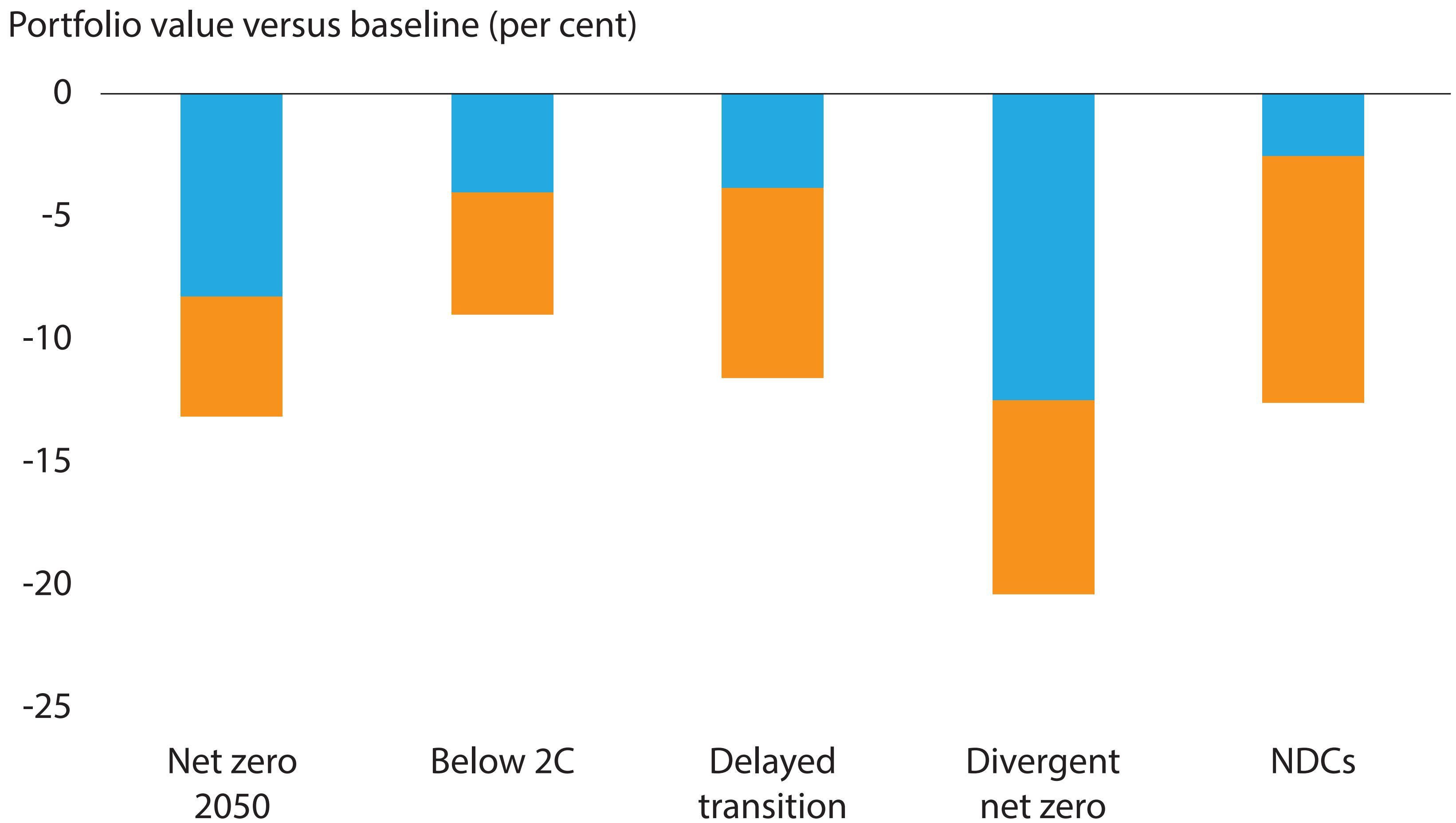
These risks, and the tools to assess them, are evolving rapidly. It's important to take them seriously and fully understand the broader impacts, including potential behavioural responses. Following this work, we have a better understanding of how climate risks might impact financial markets. But there is more for us and for market participants to do. And to that end, we are further clarifying our expectations for banks and insurers through our recently published consultation paper.

Let me pause briefly on commercial property since assets here might also be vulnerable to sudden repricing. We are already seeing evidence of a 'green premium' being paid for more sustainable office space[13]. That suggests that some climate risks are already priced in.

However, a sharp reassessment of physical risks or the likelihood of a sharp and disorderly transition, may lead properties that are more exposed to severe weather events or that do not live up to sustainability standards to face a heavier discount. So there is work to do here too.

Climate risks becoming more proximate can also impact financial stability through the withdrawal or a higher cost of insurance. As flood risks intensify, insurers may withdraw coverage or increase price. This is already happening in the US, where policy non-renewals correlate with regional climate risks[14].

Chart 4. Climate re-pricing of a long-duration G7 sovereign bond portfolio



Source: Measuring climate-related financial risks using scenario analysis (Holden et al 2024).

Prospective homebuyers in flood prone areas might anticipate reduced insurance availability and higher premia, demanding discounts to house prices to compensate. Our November 2024 *Financial Stability Report* found that in the most pessimistic climate scenarios, the 1% of properties most exposed to increases in flood risk could lose around 20% of their value.

And the potential fall in house prices for the 10% most exposed areas would be, on average, 6.5 times larger than in areas with a median level of risk[15].

Mortgage lenders' exposures are sensitive to house prices. A price fall would increase the loss given default on a property. If more properties were uninsured, potential losses faced by lenders in the event of flooding would also increase. We could see mortgage prisoners, where existing mortgage holders are unable to refinance their homes. Our CBES analysis found that in our late and no action scenarios mortgage losses faced by banks are around four times larger than in our early action scenario.

Changing insurance availability can also impact commercial real estate. It is estimated that 10% of commercial properties are in flood plains and the impact of flooding on affected businesses can be severe (Crampton *et al* 2025). The need for businesses to self-insure could also put downward pressure on their investment expenditure.

In the UK we have Flood Re for residential properties – a joint reinsurance initiative between the Government and the insurance industry. This limits the short-term financial impact of flooding on households, as around 90% of residential properties are insured. But commercial properties are not covered. And as physical climate-related risks increase over the long term, and the Flood Re scheme ends, financial stability risks could develop. What happens as we approach the end of Flood Re matters a lot.

These examples highlight how some of the risks to the financial system are becoming more proximate. Since the Bank first started its thinking on how climate change matters for the financial system we are in a much better place – managing climate risks is becoming increasingly embedded in our analysis and our actions, and our increased understanding of a host of risks has led us to feel better prepared.

However, there is much more for us and market participants to do to minimise both the likelihood of climate risks materialising and their impact if they do.

Conclusion

So where does this leave us? In 2019 I gave a speech titled *Avoiding the storm*. As I have hopefully highlighted for you this evening, the storm, or at least the beginnings of it, is already upon us. And so it is vital for us now to work out how to 'weather it'.

What does that mean for the real estate sector? Climate risks are real and tangible, and as they become more imminent, property valuations may change rapidly. Real estate owners and lenders could face significant risks, particularly if insurance protection becomes unavailable.

To manage these risks and support the transition to net zero, investment for adaptation and mitigation is crucial. Under current Government plans, all commercial property will need an EPC rating of B or above by 2030. 83% of commercial buildings in major cities currently fall below that standard[16]. The cost of transition will be substantial and require significant financing. Without the necessary funding, we risk stranded or 'zombie' properties.

As the central bank, our role is to provide the right macroeconomic and financial environment for this investment. That means two things: ensuring price stability and maintaining a strong and resilient financial system. And we need to do that in the face of physical and transition shocks. These are the most important actions we can take to ensure a stable foundation for economic growth. Our doing that will support us all in weathering the storm. ■

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Endnotes

1. IPCC — Intergovernmental Panel on Climate Change.

2. Global Warming of 1.5°C, IPCC (2020).

3. Climate change: Supporting farmers and growers - House of Lords Library.

4. Impact of Climate Change on the UK Food System | Published in FSA Research and Evidence.

5. Acute physical impacts from climate change and monetary policy (2024), NGFS Technical Document.

6. In Ficarra and Mari (2025), a one standard deviation increase in the number of UK floods was found to reduce regional output by 1% and raise regional inflation by 0.5% at the two-year horizon. However, the aggregate economy-wide impact can differ significantly depending on the sectoral composition and position in the supply chain of the area affected by flooding. Li (2024) applies the same identification approach across countries and finds that flooding has a much larger inflationary effect in developing economies relative to advanced ones, because of the larger supply shock it triggers.

7. In 2021, the EU transitioned from Phase 3 to Phase 4 of the EU ETS. The UK left and established the UK ETS, which started in Phase 1. Both ETSs have scheduled a reduction in the supply of carbon permits, a decreasing share of permits being given out for free, and an expansion of sectoral coverage over the period 2021 to 2030.

8. For comparability across shocks, our estimates in Chart 3 are standardised to increase energy price inflation by 1 percentage point (at peak), which is a common scaling choice in the literature for ease of interpretation (see, for example, Känzig (2025) and Ortubai et al (2025). It is worth noting, however, that this scaling choice means we are considering a particularly large shock in the carbon market: roughly 15 times bigger than a 'typical' (1 standard deviation) shock over the sample period. The oil and gas price shocks needed to increase energy price inflation by 1 percentage point (at peak) are 5 times and 3 times bigger than a 'typical' (1 standard deviation) shock over the sample period, respectively.

9. Avoiding the storm: Climate change and the financial system - speech by Sarah Breeden | Bank of England and From hot air to cold hard facts - speech by Andrew Hauser | Bank of England.

10. Financial Stability Report - November 2024 | Bank of England.

11. Measuring climate-related financial risks using scenario analysis | Bank of England.

12. System-wide exploratory scenario | Bank of England.
13. Sustainability and Value | Capital Markets: Central London Offices Research | 2023 | JLL Research.
14. Chairman Press | Chairman's Newsroom | Chairman | US Senate Committee on The Budget.
15. Evidence is emerging that higher insurance premia are already affecting home prices in parts of the US, see for example Eastman, Evan and Kim, Kyeonghee and Zhou, Tingyu, Homeowners Insurance and Housing Prices (June 03, 2024). Available at SSRN: Homeowners Insurance and Housing Prices.
16. British Property Federation.

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