Global trade in the energy transition: Principles for clean energy supply chains & carbon pricing

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Energy Transitions Commission

Briefing Note

The Energy Transitions Commission (ETC) is a global coalition of leaders from across the energy landscape committed to achieving net-zero emissions by mid-century, in line with the Paris climate objective of limiting global warming to well below 2°C and ideally to 1.5°C.

Our Commissioners come from a range of organisations – energy producers, energy-intensive industries, technology providers, finance players and environmental NGOs – which operate across developed and developing countries and play different roles in the energy transition. This diversity of viewpoints informs our work: our analyses are developed with a systems perspective through extensive exchanges with experts and practitioners. The ETC is chaired by Lord Adair Turner who works with the ETC team, led by Ita Kettleborough (Director), and Mike Hemsley (Deputy Director). The lead author of this briefing note is Rose Dortch (Head of Global Programmes).

The ETC's *Global trade in the energy transition: Principles for clean energy supply chains & carbon pricing* briefing was developed in consultation with ETC Members, but it should not be taken as members agreeing with every finding or recommendation.

The ETC team would like to thank the ETC members, member experts and the ETC's broader network of external experts for their active participation in the development of this briefing note.

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Introduction

Global greenhouse gas (GHG) emissions have not yet peaked – atmospheric concentrations continue to rise and global temperatures are increasing faster than previously projected.[1,2] Rapid emission reductions are essential if the world is to limit global warming to the "well below 2°C" target agreed at COP21 in Paris.

In all sectors of the economy, however, there are technologies which can drive the required emissions reduction, but with a crucial distinction between:

- **Sectors where low carbon technologies have already or will soon reach cost parity** with traditional alternatives, reflecting dramatic cost reductions over the last 10 to 15 years.
  - The per-unit price for solar PV modules has fallen by 94% from 2011 to 2025, and by more than 60% since 2020 alone.[3]
  - Global onshore wind turbine prices have decreased over 60% between 2010 and 2024.[4]
  - The average lithium-ion battery pack price has fallen by 92% between 2010 and 2024, whilst energy density doubled over the same period.[5, 6]
  - In 2023, over 60% of electric vehicles (EVs) sold in China were cheaper than their internal combustion engine (ICE) counterparts.[7]
- **Sectors where new clean technologies are expected to remain more expensive than fossil-based alternatives** for decades to come – and, in some cases, indefinitely. Particularly in the so-called hard-to-abate sectors of long-distance transport (e.g., aviation and shipping) and heavy industry (e.g., steel, chemicals, and cement), clean technologies are technically feasible but come with a significant green cost premium.

In the sectors where costs are close to or at parity, it is essential to grasp the potential for massive cost-effective deployment which now exists. In the sectors facing a green cost premium, it is vital to have policies which make decarbonisation economic despite this premium. But in all sectors, tensions related to international trade could significantly slow the pace of the transition. This reflects:

- **China's dominance in the development, manufacturing, and deployment of many clean technologies:** On the one hand cost reductions achieved in China could now make it possible to accelerate cost-effective decarbonisation around the world. On the other, growing concerns about the economic, employment, and security consequences of over reliance on China have led many countries to introduce policies to develop domestic supply chains, including through the use of tariffs on China's clean technology supply. Even before President Trump's new tariff measures, the United States (US) had already imposed tariffs of 100% on Chinese-made EVs, 50% on solar cells, and 25% on EV batteries, critical minerals, steel, and aluminium.[8] Similarly, the European Union (EU) has initiated investigations into Chinese subsidies for clean technology products, and imposed tariffs on EV imports.[9]

1 World Meteorological Organization (2024), *Record carbon emissions highlight urgency of Global Greenhouse Gas Watch.*

2 IPCC (2023), *Climate Change 2023: Synthesis Report.*

3 In parallel, average efficiency of a typical silicon module has increased from 15.4% in 2012 to 22.7% in 2025. See BNEF (2025), *Today's Photovoltaic Modules are Better as Well as Cheaper.*

4 Global average (including China) on a per MW-basis, including installation costs. Despite easing cost pressures, wind turbine prices in late 2024 stayed 38% above pre-pandemic levels as suppliers targeted higher margins. See BNEF (2024), *Wind Turbine Price Index 2H 2024: Still Aloft.*

5 Volume-weighted average across passenger EVs, commercial vehicles, buses, 2- and 3-wheelers, and stationary storage; price includes cell and pack. 2024 saw a 20% year-over-year decrease from 2023, the largest drop since 2017. See BNEF (2024), *2024 Lithium-Ion Battery Price Survey.*

6 BNEF (2023), *Long-term Electric Vehicle Outlook.*

7 IEA Commentary (2024), *Cheaper electric cars: the key to unlocking mass-market adoption.* Available at https://www.iea.org/commentaries/cheaper-electric-cars-the-key-to-unlocking-mass-market-adoption. [Accessed April 2025].

8 PV Magazine (2024), *U.S. increases and extends clean energy import tariffs on China.* Available at https://www.pv-magazine.com/2024/09/16/u-s-increases-and-extends-clean-energy-import-tariffs-on-china/. [Accessed May 2025].

9 Financial Times (2025), *EU probes BYD plant in Hungary over unfair Chinese subsidies.* Available at https://www.ft.com/content/0ef28741-6194-4ee6-8f23-945415de7458. [Accessed May 2025].

- **The challenge of international competition in the hard-to-abate sectors:** Since new technology application in these sectors faces a green cost premium, there is a strong case for carbon pricing to ensure decarbonisation. But given the international nature of these sectors,[10] carbon prices cannot be imposed in one country alone, since local firms will lose competitiveness, production will move to other locations, and global emissions reductions will not be achieved. In response, the EU has introduced a carbon border adjustment mechanism (CBAM) but this remains a contentious policy in some countries.

This briefing note, therefore, sets out the ETC's position on these two areas of contention, covering in turn:

- **China's supply chain dominance and resulting trade issues,** with six principles to guide a balanced and constructive policy response.
- **The need for carbon prices and international coordination in the hard-to-abate sectors,** outlining the strong rationale for CBAMs where global carbon pricing is not yet feasible, and proposing safeguards to ensure such mechanisms remain non-protectionist.

10 The international nature of sectors refers to the characteristic of that sector to either be traded internationally (e.g., steel and chemicals) or to be inherently international (e.g., shipping and aviation).

1 China's supply chain dominance and resulting trade issues

China's dominant role in clean technologies reflects technological leadership, economies of scale, and learning curve effects. In an ideal world, the cost reductions China has achieved would be celebrated for enabling a more affordable global transition to net-zero economies. However, a mix of economic and national security concerns has led many countries to seek reduced reliance on any single nation — and in particular, on China. In this section, we therefore assess the drivers of China's technological and cost leadership and suggest six principles to guide a balanced policy response.

1.1 Key drivers of China's success

China has established itself as the dominant force in global clean energy manufacturing [Exhibit 1.1], accounting for an estimated 70% of total production across six key clean technologies. Its share of global manufacturing capacity for these technologies ranges from 40% to as much as 98%, depending on the component. Today, China produces more than 80% of the world's battery cells and solar PV modules, 65% of wind nacelles[11], and two-thirds of all electric vehicles. It also plays a crucial role in the midstream processing of critical minerals, refining 65% of the world's lithium, over 75% of its cobalt, and nearly all graphite anodes. This dominance was already significant in 2021 but has increased still further over the last four years.

China's dominance of clean technology supply chains has grown since 2021

Installed global manufacturing capacity by country/region, 2023

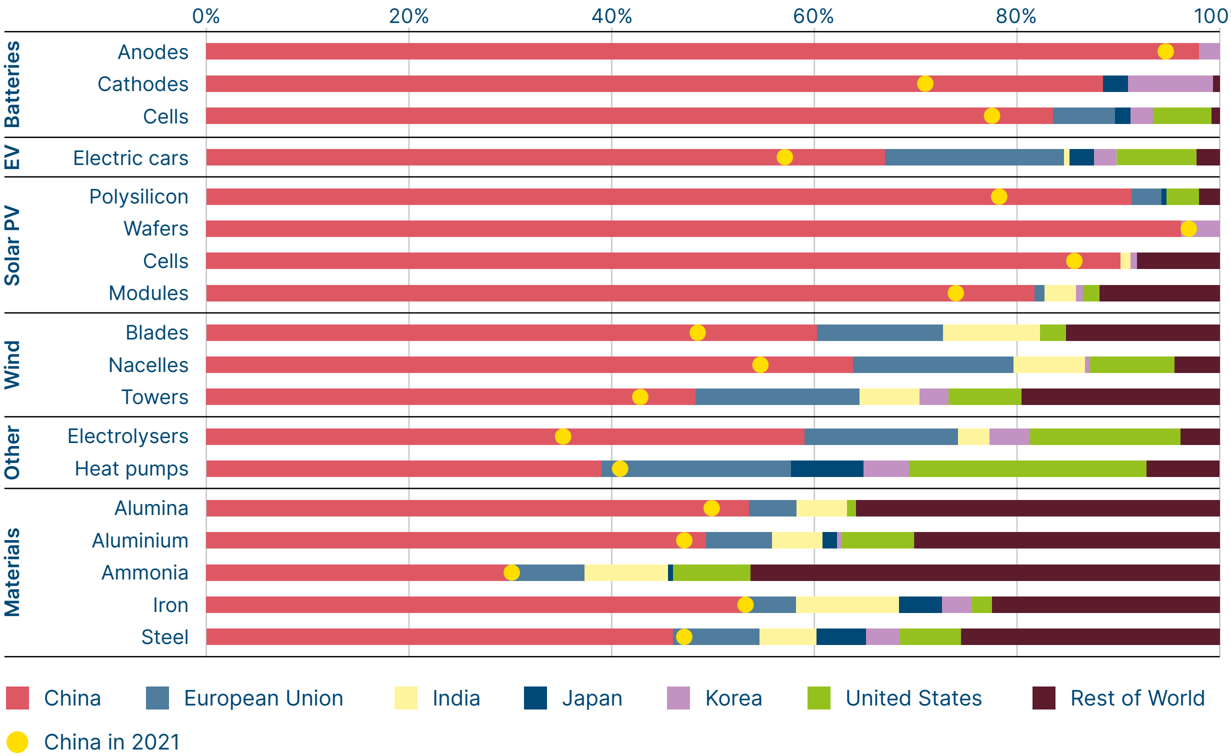


EXHIBIT 1.1

Note: RoW = Rest of World. "Electric cars" values are calculated based on 2023 production numbers, adjusted according to the utilisation rates of car assembly plants in the region.

Source: IEA (2024), *Energy Technology Perspectives*.

11 Nacelle is the housing or enclosure on a wind turbine containing the generator, gearbox and other key components that convert wind energy into electricity.

China's dominance in these technologies is sometimes attributed to lower labour costs and less stringent environmental regulations. While these factors did play a role in the early stage of China's clean tech industry development (as in other sectors of the economy), their significance has steadily declined. Increased automation has reduced the importance of low-cost labour, wages have risen, and environmental standards have improved.[12] Rather, there are five key factors driving the structural cost advantage which China has now achieved [Exhibit 1.2].

- **Strategic, coordinated vision**: China's Five-Year Plans establish clear targets for both the development and deployment of clean technologies, ensuring long-term policy consistency. China's strategic focus on clean energy first gained prominence in the 11th Five-Year Plan (2006–2010), which marked a decisive

Key drivers of China's clean tech advantage

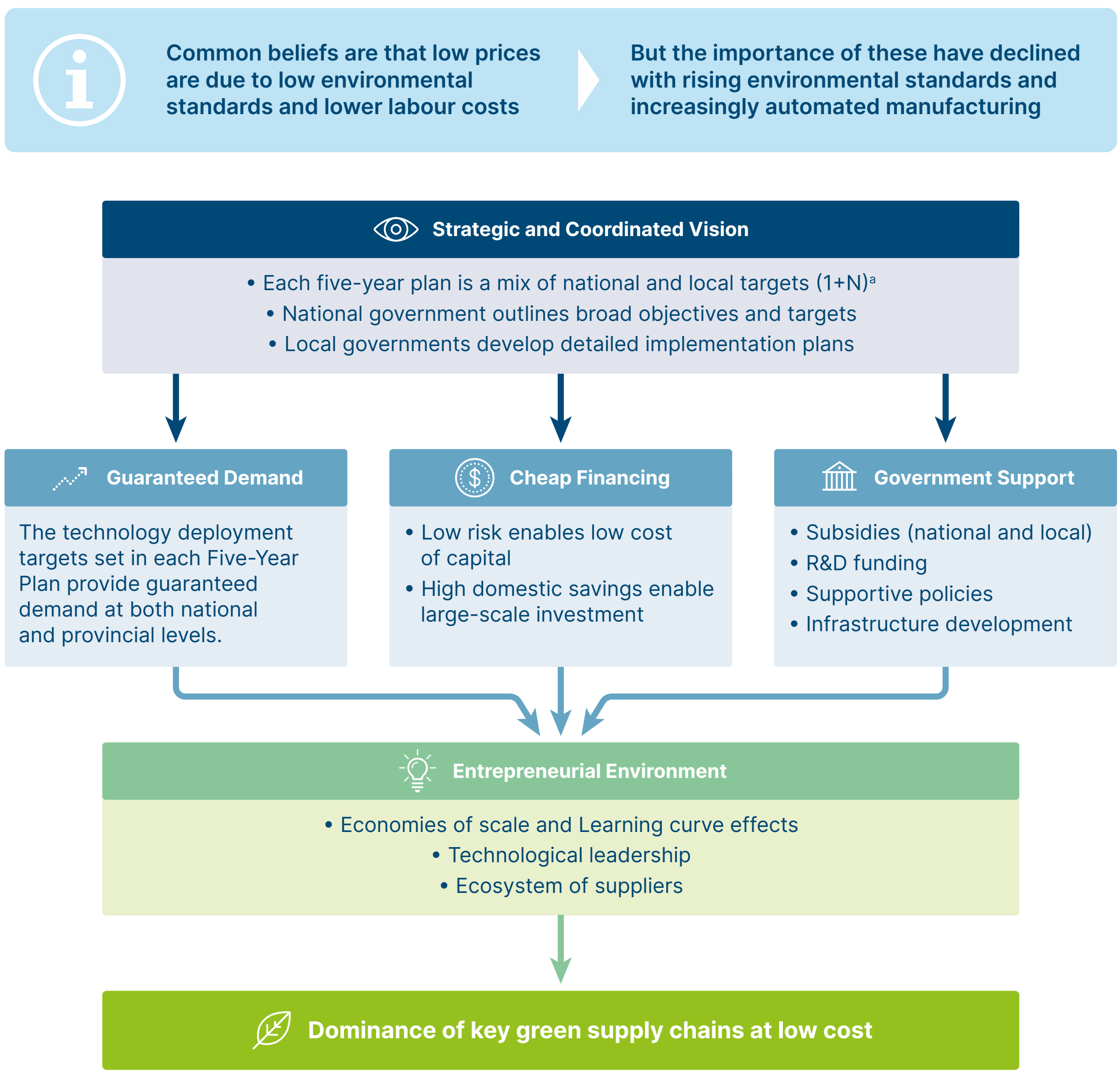


EXHIBIT 1.2

Note: (A) "1+N" refers to China's policy framework in which one overarching plan for the nation ("1") is supported by a series of detailed sectoral or regional policies ("N") to guide implementation.

Source: Systemiq analysis for the ETC.

12 China has steadily strengthened its environmental standards over the past several decades. Though its grid still relies on coal power generation, its share has decreased from 80% to 60% in recent years. Additionally in 2021, the Ministry of Ecology and Environment (MEE) launched a framework requiring large and medium-sized enterprises to disclose their GHG emissions, enhancing transparency and accountability in corporate environmental performance. See Green Finance and Development Center (2023), *Green Finance trends in China (1): China's Green Finance Policy Landscape*. Available at https://greenfdc.org/green-finance-trends-in-china-1-chinas-green-finance-policy-landscape/. [Accessed May 2025]. Additionally, leading Chinese companies have committed to ambitious sustainability goals e.g., LONGi, the worlds' leading PV module manufacturer has pledged to power all its operations with 100% renewable energy by 2028 reflecting the broader corporate shift towards greener practices. See LONGi, *RE100*, available at https://www.longi.com/en/sustainable-development/promise/re100/. [Accessed May 2025].

shift toward scaling renewable energy and improving energy efficiency. This plan laid the foundation for the growth of the "new three" industries – solar PV, batteries, and EVs – positioning them as core pillars of China's clean technology strategy.[13]

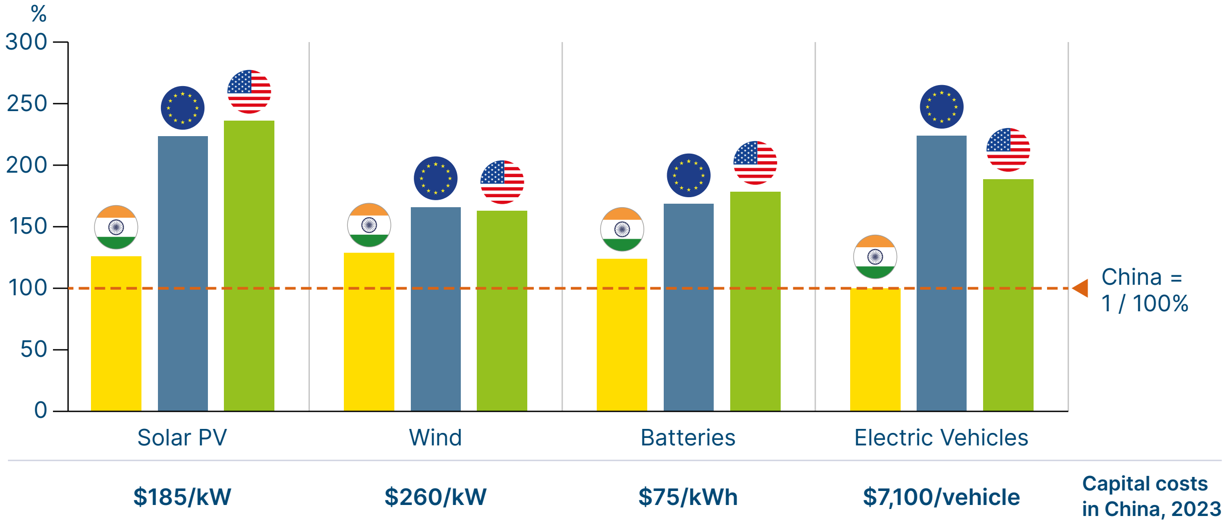
- **Guaranteed demand:** Deployment targets create predictable local demand, providing a reliable market for new technologies. For example, in the 13th five-year plan (2016–2020), the government had a national target of 110 GW of installed solar capacity[14] while individual provinces also set their own targets. This guaranteed manufacturers significant volumes of demand. Approximately 50% of global solar PV and wind installations and EV sales are in China.
- **Cheap funding:** Guaranteed demand reduces investment risk, which in turn lowers the cost of capital for clean technology projects. This predictability, combined with China's high domestic savings rate and government provision of concessionary loans, enables access to low-cost financing, facilitating large-scale investment in innovation and manufacturing capacity.
- **Government support** (including national and local subsidies, R&D funding, supportive policies, and investments in infrastructure): While these measures have been instrumental in scaling China's clean technology industries, it is important to note that similar strategies have been employed by other countries as well, such as Germany's support for solar PV production in the 2000s.
- **Entrepreneurial environment:** Reflecting a strong scientific and research base, widespread technical skills, and a dynamic entrepreneurial ecosystem, China has established technological leadership in cutting-edge clean technologies – such as batteries, EVs, solar panels, and wind turbines – while also becoming the world's lowest-cost producer, giving it a structural competitive advantage.

These factors have enabled China to achieve economies of scale, accelerate learning curves, and develop a fully integrated supplier ecosystem across the entire value chain for multiple clean technologies to a point where China now dominates green technology supply chains at low cost [Exhibit 1.3].

EXHIBIT 1.3

China is more cost competitive than other countries across all major clean energy technologies

Indicative capital costs indexed against China, 2023



Note: Capital costs are shown per unit of annual rated capacity. Solar PV includes polysilicon, wafer, cell and module production facilities; batteries include cell, anode and cathode production facilities; wind includes nacelle, tower and blade facilities. Costs refer to greenfield, non-integrated facilities where these attributes could be isolated in the data and constitute averages across plants of different sizes today. Data gaps were filled using regional multipliers based on differentials in cost for constructing other facilities where more data are available. No explicit policy incentives (e.g., investment tax credits) are applied in this assessment. USD = USD (2023, MER) (IEA (2024), *Energy Technology Perspectives).*

Source: Systemiq analysis for the ETC based on IEA (2024), Energy Technology Perspectives. *This is a work adapted by the ETC from IEA material and ETC is solely liable and responsible for this derived work. The derived work is not endorsed by the IEA in any manner.*

13 Government of China (2006), *Guidelines of the Eleventh Five-Year Plan for National Economic and Social Development.* Available at https://policy.asiapacificenergy.org/sites/default/files/11th%20Five-Year%20Plan%20%282006-2010%29%20for%20National%20Economic%20and%20Social%20Development%20%28EN%29.pdf.

14 China's 2020 solar target of 110 GW, split into 105 GW of solar PV and 5 GW of concentrating solar power (CSP). See PV Tech (2017), *China's 13th Five-Year Plan for solar – a look at 2017 and beyond.*

1.2 Six principles for local supply chains development

In a perfect world, one without geopolitical tensions or supply chain risks, China's progress in clean technologies and dramatic cost reductions might be viewed as a global asset — accelerating and lowering the cost of the transition to net-zero emissions worldwide. But multiple factors make some countries concerned about China's dominant role. These include:

- **Concentrated and lengthy supply chains:** The past five years have made these vulnerabilities clear – COVID-19 lockdowns severely interrupted solar and semiconductor supply chains;[15,16] shipping congestion contributed to rising wind turbine prices;[17] and since 2021, the lead times for cables and large power transformers have nearly doubled, with wait times for certain specialised components (e.g., current cables commonly used in long-distance transmission) now exceeding five years.[18]
- **Implications of import dependency for "energy security":** Increased greatly in Europe after Russia's invasion of Ukraine and the subsequent dramatic reduction in Russian gas supply to Europe.
- **Employment impacts from high import reliance:** Especially in labour-intensive sectors like automotive manufacturing, where growing import shares can threaten domestic employment and industrial capacity.
- **Environmental and human rights concerns:** These include concerns about the carbon intensity of production and use of forced labour in Chinese clean energy supply chains. However, industry action and supply chain traceability is moving to address these concerns.[19]

Countries therefore need to design clean tech supply chain strategies that address these concerns where valid, but also support continued and ideally accelerated cost reduction in key clean technologies [Exhibit 1.1].

To guide decision-making on trade and manufacturing of clean technologies, the ETC proposes six principles:

1. Aim for diversified supply chains but not complete autarky.
2. Think straight about different dimensions of "security".
3. Vary economic policy by sector to reflect different starting points and inherent characteristics.
4. Use tariffs in a fact-based and WTO compliant fashion.
5. Focus primarily on the location of employment and value-add, rather than ownership.
6. Work with China to increase climate finance flows to lower income countries supporting the accelerated deployment of clean technologies.

1.2.1 Diversified supply chains but not complete autarky

Complete autarky in clean technologies is neither realistic nor desirable – first, it would deny countries the benefits of the technological progress and cost reduction China has already achieved and second, it would exclude the stimulus to cost reduction and innovation that foreign competition can provide. For example, research from BloombergNEF found that under a net-zero scenario, decarbonising the power sector by 2050 would require $265 billion more investment in Europe and $135 billion more in the US if solar modules and battery cells are domestically sourced rather than procured through lowest-cost global supply chains.[20]

At the same time, it is both legitimate and rational for countries to reduce dependence on overly concentrated foreign supply chains, while also fostering domestic employment and value creation in sectors that will be critical to future economic growth. This implies that:

15 International Solar Alliance (2023), *Building Resilient Global Solar PV Supply Chains.*

16 World Electric Vehicle Journal (2022), *The "Semiconductor Crisis" as a Result of the COVID-19 Pandemic and Impacts on the Automotive Industry and Its Supply Chains.*

17 ETC (2024), *Overcoming Turbulence in the Offshore Wind Sector.*

18 IEA (2025), *Building the Future Transmission Grid.*

19 S&P Global (2025), *Navigating supply chain resilience amid rising geopolitical risk.* Available at https://www.spglobal.com/en/research-insights/market-insights/geopolitical-risk/supply-chain-resilience. [Accessed September 2025].

20 BNEF (2025), *Onshoring Raises Costs, Constrains Clean Energy Deployment.*

- Governments should focus on building domestic supply chains in sectors where they could be cost competitive with potential for significant sustainable job creation.
- The aim should be for significant local content[21], but without excluding investment and trade flows. The EU Net Zero Industrial Act (NZIA) target that 40% of clean deployment needs should be met with local manufacturing by 2030[22] is a reasonable objective. Objectives embedded in India's Production Linked Incentives[23] and the US Inflation Reduction Act (IRA)[24] also reflect this balance approach.
- Countries should welcome foreign products where it will be difficult to develop local substitutes without excessive subsidy or a significant cost penalty – Chinese-made solar panels are an example of this.

The challenge will be to ensure that any policy interventions on supply chains continue to move technologies down the cost reduction trajectories

Case study of Solar supply chains: Initially, near-shoring dynamics can be seen as moving back and up a clean energy technology "learning curve", which is why any such efforts must be accompanied by policies to ensure technology costs continue to go down

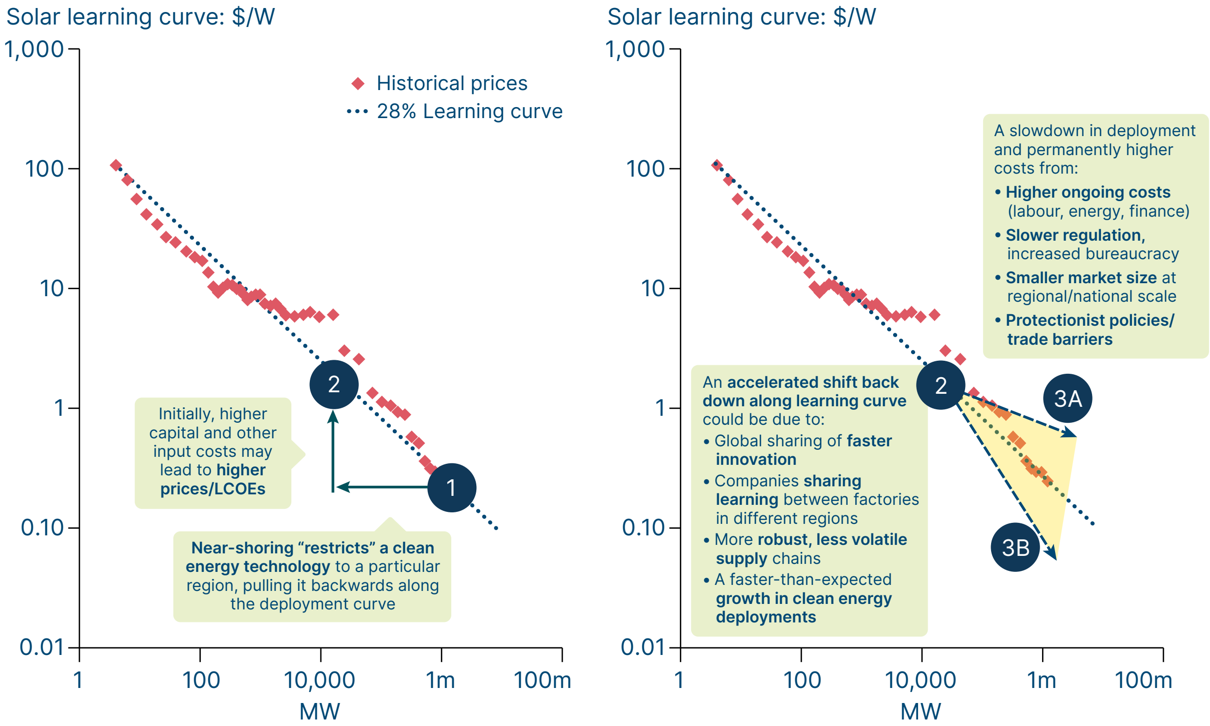


EXHIBIT 1.4

Source: ETC (2023), *Better, Faster, Cleaner: Securing clean energy technology supply chains.*

1.2.2 Thinking straight about "security"

In trade related debates, the term "security" is used in a variety of ways. It is therefore essential to distinguish between different issues and to assess carefully where important "security" concerns do and not exist. In particular:

- **Energy security:** It is important to recognise that the supply risks associated with clean technology imports are far smaller than those which result from import of fossil fuels for immediate consumption.

21 Local content refers to the proportion of a product's value that is generated from goods, labour, or services that are sourced domestically, rather than imported from abroad.

22 European Commission (2024), *The Net Zero Industry Act explained.*

23 The Production Linked Incentives Scheme aims to build an ecosystem for manufacturing of high efficiency solar PV modules in India and thus reduce import dependence in the area of renewable energy. See Ministry of New and Renewable energy, *Production Linked Incentive (PLI) Scheme: National Programme on High Efficiency Solar PV Modules.* Available at https://mnre.gov.in/en/production-linked-incentive-pli/. [Accessed May 2025].

24 In August 2022, the U.S. government approved the Inflation Reduction Act (IRA) of 2022, combining the objectives of reducing domestic inflation while tackling climate change. See IEA (2025), *Inflation Reduction Act of 2022.* Available at https://www.iea.org/policies/16156-inflation-reduction-act-of-2022. [Accessed May 2025].

If piped gas supplies are cut off as a result of geopolitical conflict, there is an immediate shortage of energy to meet demands. If solar panels and wind turbine supply is restricted, the importing country continues to enjoy the output from the panels or turbines previously bought.

- **National security:** Here, trade dependency risks could include both:
  - The possibility that reliance on another country for products with military applications (e.g., certain types of semiconductors) could lead to supply disruptions during periods of geopolitical tension.
  - The danger that remote software control of capital assets could be deliberately exploited or be particularly vulnerable to cyberattacks.

In general, the clean technologies driving the energy transition are not entirely militarily relevant; and in relation to remote software control risks it is important to recognise that different technologies fall along a spectrum of risk, where **software not hardware** is likely to see the greater risk:

- At the highest risk are technologies like grid control **software**, which are central to nationally important infrastructure, involve real-time data flows, and could be vulnerable to cyber threats or external manipulation.
- At the low-end of the risk spectrum are battery cells and packs, electrolysers, and solar PV modules, all of which present minimal security concerns, as they are primarily **hardware**-based with no significant data or control vulnerabilities.

Each technology should be assessed on a case-by-case basis, and where there are perceived risks governments should assess mitigation options. For example, in the US, and including through institutions like the Committee on Foreign Investment, there is increased scrutiny on the provision of Chinese communication software within connected devices such as batteries and vehicles, though this doesn't extend to outright bans on the sale of key hardware components such as battery cells or packs, or solar modules.[25]

1.2.3 Economic development objectives: Optimal approach varying by sector

Apart from any security related objectives, the key rationale for domestic supply chain development is economic – to secure value added activity and employment in technologies which will play a major role in future economic growth.

The feasibility and the benefits of such development is likely to vary significantly by specific technology. Key factors to consider include the level of existing employment, the extent to which products are customised vs. standardised, the level of government support required to protect or create a domestic manufacturing base, and the cost penalty of excluding imports.

Applying this to two clean technologies, it is clear how significantly these factors can differ:

- **Solar panels** are highly standardised, mass-produced products requiring little customisation for different markets. Many countries, including all of Europe, have trivial existing employment at risk and given China's massive scale advantage, attempting to create a domestic supply chain in solar PV would likely require either very high subsidy or accepting a much higher solar PV price. Furthermore, the employment creation opportunity would be very small. Many countries may therefore prefer to simply buy solar panels from China or instead from India – which given the huge potential scale of domestic demand, may be able to achieve somewhat comparable costs.
- **EVs,** conversely, require significant design customisation to meet country regulations or consumer preferences in different countries, and many countries - whether in Europe or elsewhere (for instance, Malaysia, Thailand and Mexico) - have significant local employment in the automotive industry. Meanwhile EV battery manufacturing is often located close to vehicle manufacturing to reduce transport costs and aid just-in-time delivery. As a result, there may be greater opportunity for well designed policy to boost domestic EV and battery manufacturing while avoiding a significant cost penalty.

25 Reuters (2024), *Exclusive: US to propose ban on Chinese software, hardware in connected vehicles.* Available at https://www.reuters.com/business/autos-transportation/us-propose-barring-chinese-software-hardware-connected-vehicles-sources-say-2024-09-21/#:~:text=The move is a significant,the rules, the sources said. [Accessed May 2025].

Countries aiming to establish or regain competitive advantage in clean technologies should also seek to enable the nearshoring of production of those technologies that are in globally short supply. As outlined in the ETC's 2023 report *Better, Faster, Cleaner: Securing clean energy technology supply chains*, products such as large power transformers, high voltage DC cables and wind turbine installation vessels already face acute supply constraints and long lead times.[26] For these items, supply bottlenecks imply guaranteed demand in the years ahead, offering a compelling case for domestic or nearshore production capacity as a means to secure supply and enhance resilience. Similarly, a focus on future innovative technologies such as floating wind, or tidal and wave power may reap longer-term benefits.

1.2.4 Using tariffs in a fact-based and WTO-compliant way

Many countries are currently using a combination of tariffs (e.g., on imported EVs, or solar panels) and subsidies (e.g., tax breaks, government-backed loans, direct subsidies) to incentivise the development of low-carbon manufacturing and industry.

Both can play a role but should be deployed in ways that neither permanently and significantly increase the cost of clean technologies nor exclude the beneficial stimulus of international competition. This implies a preference for:

- **Time-bound subsidies, not permanent tariffs:** Targeted, time-limited subsidies can support the growth of domestic industries without creating long-term inefficiencies. Permanently protecting structurally higher-cost industries risks making clean technologies more expensive and less competitive, ultimately slowing their adoption. Governments should focus on policies that provide short-term support while ensuring industries become cost-competitive over time.
- **WTO compliance:** Where tariffs are considered, they should be based on a clear, objective assessment of the scale of existing subsidies in other countries, in line with WTO rules.[27] By aligning tariff policies with international trade norms, countries can foster domestic manufacturing while maintaining a fair and open global market for clean technologies.

1.2.5 Focus on location, not ownership

In seeking to develop domestic clean technology manufacturing, there is a strong argument for focusing on the location of production not the ownership of assets. Investment, job creation, and technology transfer are driven by the physical presence of manufacturing operations, and do not necessarily require domestic ownership.

- **Foreign-owned companies can still deliver significant economic value within a country by providing employment and contributing to industrial output.** For example, the UK's automotive sector is now almost entirely foreign-owned. But in 2023, this sector directly employed nearly 200,000 people and produced over 900,000 vehicles – at least 95% of which came from non-UK owned manufacturers.[28]
- **Beyond job creation, inward investment plays a critical role in technology transfer and skills development.** China's successful industrial development in the 1990s and 2000s depended significantly on deliberately encouraged inward investment. Similarly, Toyota's investments in the US in the early 1990s led to significant knowledge transfer, particularly through the introduction of the Kaizen manufacturing philosophy, which revolutionised efficiency and quality in American auto plants.[29] More recently, Samsung's investment in Indonesia has not only created thousands of jobs in electronics manufacturing but has contributed to the country's rise as an electronics exporter.[30]

26 ETC (2023), *Better, Faster, Cleaner: Securing clean energy technology supply chains.*

27 Under WTO rules, tariffs are governed by the Most Favoured Nation (MFN) principle, requiring members to apply the same tariffs to all trading partners, with some exceptions. Members also commit to "bound duties" – maximum tariff levels negotiated at the WTO – though they may apply lower "MFN applied" or preferential tariffs under certain conditions, such as trade agreements or development exceptions. See WTO, *Let's Talk Tariffs.* Available at https://www.wto.org/english/res_e/webcas_e/ltt_e/ltt2_e.htm. [Accessed May 2025].

28 The Society of Motor Manufacturers (2024), *SMMT Motor Industry Facts 2024.*

29 Mishina, Kazuhiro (1992), *Toyota Motor Manufacturing, U.S.A., Inc.*

30 Intimedia (2025), *Indonesia's Electronics Industry Thrives: The Role of PT Samsung Electronics Indonesia in Driving Export Growth and Domestic Manufacturing.* Available at https://intimedia.id/read/indonesias-electronics-industry-thrives-the-role-of-pt-samsung-electronics-indonesia-in-driving-export-growth-and-domestic-manufacturing. [Accessed April 2025].

- **When gaps in knowledge, skills, or cost competitiveness are large, catching up without leveraging industry leaders' expertise is difficult, if not impossible.** The failure of BritishVolt, a UK-based battery startup, illustrates this challenge: despite significant government support, it struggled due to a lack of technical expertise, proven technology, and stable customers.[31] Similarly, the failure of NorthVolt in Sweden has shown the difficulty of rapidly building industrial capacity without the benefit of existing company technical expertise and the ability to transfer best practice from other factory locations.[32]

Simply assembling components without deeper integration into the supply chain is unlikely to drive meaningful technology transfer. Thus, while welcoming and supporting inward investment, countries should focus on ensuring significant local content (where possible) and attracting high-value manufacturing and R&D investments that bring lasting industrial capabilities. Several policy tools can be deployed to achieve this including encouraging or requiring joint ventures (JVs), imposing local content requirements, and encouraging technology licensing agreements to build local firm capabilities. For instance:

- A key element of China's early foreign direct investment (FDI) strategy was its requirement for foreign companies to form joint ventures with domestic partners. This policy was designed to facilitate technology transfer, allowing Chinese firms to gain operational expertise and technical knowledge from more advanced foreign manufacturers.
- Similarly, existing funding under the US IRA ties access to battery manufacturing subsidies to rising local content requirements, ensuring that domestic production capabilities grow alongside foreign investment.
- Indonesia has also implemented a 35% local content requirement for key industries, with discussions underway to increase it to 40% to further support domestic supply chain development.

1.2.6 Climate finance flows to support clean tech deployment in lower income countries

Rapid technological progress and falling costs have made many clean technologies increasingly competitive across global markets. In particular, solar PV paired with batteries now offers a cost-effective alternative to fossil fuel–based electricity generation in many regions.[33] EVs – including two-, three-, and four-wheelers – are also approaching cost parity with ICE vehicles in a growing number of markets.

This shift presents a major opportunity for lower-income countries to accelerate the deployment of clean energy solutions. At the same time, China's substantial manufacturing capacity and existing overcapacity mean that increased demand from developing countries could be met quickly and at low marginal cost.

Unleashing this potential requires much greater flows of international finance at affordable cost of capital, as described in the ETC's 2023 report, *Financing the Transition.*[34] Across the world, and in particular, in China, India, and Europe,[35] clean investment has been rising rapidly and broadly in line with the pace required to limit global warming to well below 2°C.[36] But investment growth in lower middle- and low-income countries has been far too slow.

As reinforced in the global finance agreement at COP29, formally known as the New Collective Quantified Goal on Climate Finance (NCQG), developed countries still committed to the Paris climate process – plus China – should work together to scale up financial flows to lower middle- and low-income countries, enabling accelerated electrification. Initially, this is likely to result in large scale purchase of Chinese clean technology products, usefully absorbing current overcapacity. At a later stage, inward investment flows could support local manufacturing in some countries.

31 Corporate Governance Institute, *What went wrong at BritishVolt?*. Available at https://www.thecorporategovernanceinstitute.com/insights/case-studies/what-went-wrong-at-britishvolt. [Accessed April 2025].

32 Spirlet, Thibault (2025), *End of the road for EV battery maker that raised $15 billion from investors including Goldman Sachs and BlackRock*. Available at https://www.businessinsider.com/northvolt-files-bankruptcy-ev-battery-maker-sweden-goldman-blackrock-vw-2025-3. [Accessed April 2025].

33 Forthcoming Systemiq analysis for the ETC on power systems transformation to be published as a major report in July.

34 ETC (2023), *Financing the Transition: How to Make the Money Flow for a Net-Zero Economy*.

35 Until recently, this group also included the US.

36 IEA (2024), *World Energy Investment*.

2 Carbon pricing and international border adjustment mechanisms

Carbon pricing is not always the most effective tool to drive decarbonisation. In some sectors, direct regulation or targeted subsidies for technology development may deliver faster and more efficient outcomes. However, there is a strong case for making carbon pricing the central policy instrument in the energy-intensive, so-called hard-to-abate sectors, which together account for approximately 15 $GtCO_2$ emissions per year, or around 30% of the global energy-related total.[37]

These sectors are either inherently international (as with aviation and shipping) or have products which are extensively internationally traded (e.g., steel and chemicals). As a result, it is not possible to proceed with carbon pricing in one country alone without producing adverse effects on relative competitiveness.

This section therefore outlines how the international coordination challenge can be addressed, covering in turn:

- The need for carbon pricing in hard-to-abate sectors.
- The international coordination challenge and the role of CBAMs.
- Why CBAMs are not protectionist, and how they are compatible with common but differentiated responsibilities.
- International coordination on measurement and the use of revenues.
- The opportunity CBAMs create for developing countries: Exploiting natural cost advantages in a global level playing field.

2.1 Hard-to-abate sectors, the green cost premium, and the need for carbon pricing

Hard-to-abate sectors are those where the technologies and methodologies to decarbonise these sectors do exist but have not yet reached, and may never reach, price parity with their more traditional, carbon-intensive counterparts.[38] These sectors are characterised by the fact that carbon either plays a key role as a material input, is produced as a byproduct, or high fuel density is required for their operation. In these cases, green alternatives to conventional methods are inherently more expensive, and this price gap may persist for the medium-to-long term, or potentially indefinitely.

- Cement produces CO_2 as a byproduct of the chemical reaction involved in the production process, meaning that decarbonisation will almost certainly require carbon capture and storage, adding an additional process step and costs.
- In aviation, long distance electric flight is unlikely to be technically feasible for many decades – if ever – and decarbonisation will therefore depend primarily on the use of sustainable aviation fuel (SAF). SAF, however, faces significant challenges in achieving cost parity with traditional fuels due to factors like the feedstocks used[39], the complex production processes involved, and the current scale limitations on production
- Decarbonisation of primary iron production could be achieved by using hydrogen instead of coking coal as the reduction agent, but latest projections for green hydrogen cost decline suggest a significant green cost premium at least until the mid-2030s.[40]

37 MPP (2024), *MPP Heavy Industry Tracker*.

38 Hard-to-abate sectors include long-distance transport (shipping, aviation, trucking) and heavy industry (aluminium, iron/steel, chemicals, and cement/concrete).

39 Sustainable carbon inputs will need to be derived either from sustainably-sourced bioresources or direct air capture (DAC).

40 MPP, *Action Sectors: Steel*. Available at https://www.missionpossiblepartnership.org/action-sectors/steel/. [Accessed April 2025].

Impact of the green premium on the cost of intermediate and final products in the hard-to-abate sectors

EXHIBIT 2.1

		Impact on final product cost $ / % price increase		Impact on intermediate product cost $ / % price increase	
Industry	Cement	**+$15,000** on a $500,000 house	+3%	**+$100** per tonne of cement (+$30 per tonne of concrete)	+100% (+30%)
Industry	Steel	**+$180** on the price of a car	+1%	**+$120** per tonne of steel	+20%
Industry	Plastics	**+$0.01** on a bottle of soda	<1%	**+$500** per tonne of ethylene	+50%*
Transport	Heavy-road transport	**No** price impact	None	**No** price impact	None
Transport	Shipping	**+$0.03** per kg of imported sugar	<1%	**+$4 million** per annum on typical bulk carrier voyage	+110%
Transport	Aviation	**+$250-500** on a 6,500-km economy flight	+50–80%	**+$1.20** per liter of jet fuel equivalent	+200%

Source: ETC (2020), *Making Mission Possible: Delivering a Net-Zero Economy.*

At the end consumer level, the price impacts of green technologies will generally be minimal, but at the intermediate business level, the cost increases can be substantial [Exhibit 2.1]:

- If shipping freight rates rose by 110% to cover the higher cost of using ammonia rather than heavy fuel oil, the cost of imported consumer goods would rise less than 1% – the equivalent of $0.03 per kg of sugar.
- And if the cost of ethylene (a key input to plastics production) rose 50%, the cost of a bottle of soda would similarly rise less than 1%.
- The only hard-to-abate sector where the impact of decarbonisation on consumer costs is likely to be significant is aviation, where the cost of fuel is 25–40% of total ticket price.

Two implications follow from these cost considerations:

- First that countries can and should impose policies to drive hard-to-abate sector decarbonisation, and they should be confident that the impact on consumer living standards will be very small.
- Second that decarbonisation of these sectors will not occur without carbon pricing, or regulation with the equivalent effect of a carbon price, to make low carbon production competitive with current high carbon intensive production methods.

2.2 The international coordination challenge and the role for CBAM

Given the international nature of several hard-to-abate sectors, achieving effective decarbonisation requires global coordination. These sectors are either actively traded across borders (e.g., steel and chemicals, electricity) or involve inherently international activities (e.g., shipping and aviation). Without coordination, these sectors would likely experience carbon leakage, where producers relocate from regions with carbon pricing to those without, undermining the efforts of countries trying to decarbonise their own industries.

The ideal solution would be globally agreed carbon prices applied to these specific sectors. In the shipping industry, the International Maritime Organisation (IMO) agreed in March 2025 to introduce a carbon levy of up to $380 per tonne on emissions above a defined intensity threshold which falls gradually over time.[41] While the scheme is estimated to be insufficiently demanding to reduce emissions at the pace defined by the IMO's previously agreed targets,[42] it is nevertheless a crucial step forward towards internationally agreed carbon pricing, with 63 countries having voted in favour, notably including China, India and Brazil.[43]

In the heavy industry sector, however, there is no international rule-making body with the authority to agree on and enforce a global carbon price. Nor has there been international consensus – particularly among major developing economies – that a meaningful carbon price should be applied globally to these sectors. In this context, countries or blocs that move forward with domestic carbon pricing for heavy industry must implement some form of border carbon adjustment to maintain a level playing field. If they do not:

- Domestic industry will face unfair competition from imports from countries which do not yet impose equivalent carbon prices; and
- True decarbonisation will not be achieved, as industrial activity and emissions will simply move to other countries.

Carbon pricing schemes are now in place across 53 countries covering over 20% of global emissions[44] but the EU is the only system which imposes carbon prices sufficiently high to have a material impact on the economics of decarbonisation in the hard-to-abate sectors.

The EU initially sought to address the international competitiveness challenge by providing heavy industry sectors with free allowances within its ETS. But this greatly reduced the incentive for decarbonisation. The EU is therefore now committed to removing the free allowances and instead introducing a CBAM which will see importers face the same carbon price that domestic production faces, with its introduction phased in by the removal of free allowances between 2026–2034.

41 Reuters (2025), *UN shipping agency strikes deal on fuel emissions, CO2 fees.*

42 Lloyd's List (2025), *MEPC83: A faltering step towards net zero.*

43 A reason for many other countries abstaining from the vote was because they didn't see the measure as ambitious enough.

44 World Bank (2025,) *Carbon Pricing Dashboard,* available at: https://carbonpricingdashboard.worldbank.org/. [Accessed May 2025].

Until now, however, key aspects of the CBAM have been insufficiently robust to create strong enough incentives for European heavy industry decarbonisation, and final investment decisions on decarbonisation products have been delayed.[45] In March 2025, the EU therefore committed to major strengthening of the CBAM regime which if implemented will create a strong momentum for the heavy industry emission reductions required to meet the EU's international commitments [Box A].

BOX A:

The European ETS and CBAM

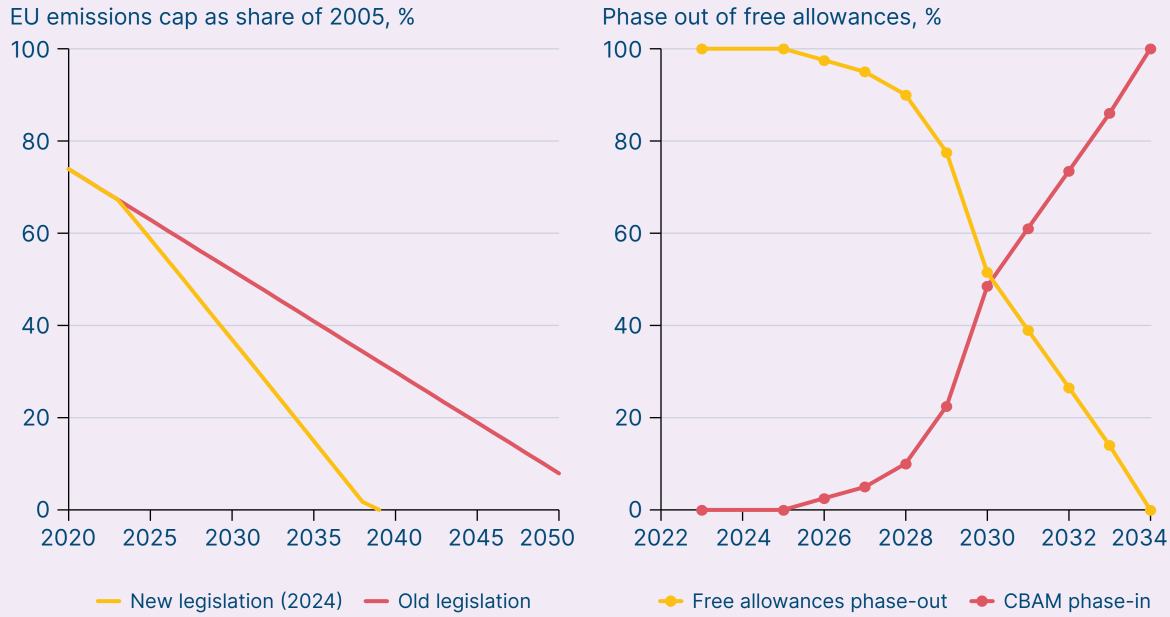
The European Union's Carbon Border Adjustment Mechanism (EU CBAM) was formally adopted in April 2023 as part of the EU's broader Fit for 55 climate package and was designed to complement the EU Emissions Trading Scheme (ETS), which was established in 2005. The price in the EU ETS is currently around €70 per tCO_2 ($80 per tCO_2[46]) – a price high enough to incentivise decarbonisation of many industrial processes – and is expected to rise further over time. Although it will expand its scope over time, the EU CBAM currently targets the emissions-intensive and trade-exposed sectors – namely iron and steel, cement, aluminium, fertilisers, hydrogen, and electricity.

The EU CBAM is being rolled out in two phases to ensure a smooth implementation process:

- **Transition phase (until December 2025):** Primarily focused on reporting embedded emissions, giving businesses and regulators time to build capacity and develop systems for emissions data collection and verification, without financial obligations.
- **Full implementation phase (beginning January 2026):** Importers must buy CBAM certificates to cover the carbon price differential between their country of origin and the EU. At the same time, free ETS allowances will be gradually phased down, starting small to avoid market disruption but completely gone by 2034 [see Exhibit 2.2].

EXHIBIT 2.2

EU ETS on track to have zero emissions allowed by 2039, with CBAM in full effect by 2034



Source: Systemiq analysis for the ETC; LHS based on EC Europa (2020), *COMMISSION DECISION (EU) 2020/1722* and RHS *based on* European Parliament PR (2022), *Climate change: Deal on a more ambitious Emissions Trading System (ETS).*

45 MPP (2024), *MPP Heavy Industry Tracker*. Available at https://www.missionpossiblepartnership.org/news/2024/4/16/new-mpp-tracker-reveals-heavy-industry-transition-has-started-but-needs-to-accelerate-sevenfold-to-meet-2030-climate-targets/. [Accessed May 2025].

46 Ember (2025), *European electricity prices and costs*. Available at https://ember-energy.org/data/european-electricity-prices-and-costs/. [Accessed May 2025].

This approach aims to ensure that domestic production and imports to the EU face the same carbon price. However, some aspects of the CBAM's initial design were not strong enough to create a strong business case for decarbonisation. As a result, several potential decarbonisation projects have been delayed before receiving final investment decision. To address these insufficiencies, the EU recently passed the Steel and Metals Action Plan, which will tighten the CBAM in three key ways[47]:

- **Export rebates** to ensure that EU companies selling their products outside of the EU are not unfairly disadvantaged relative to competitors who do not face a domestic carbon price.
- **Improved methods for estimating the emission intensity** of different production sources to address greenwashing risks.
- **Extension of the CBAM to some downstream products** to offset the danger that unfair competition simply moves downstream (e.g., from bulk steel to finished steel products).

Implementation has also proven administratively challenging – even within Europe. In Germany, fewer than 10% of the 20,000 companies expected to submit emissions reports had done so by the Q1 2024 deadline; and in Sweden, the Environmental Protection Agency reported that only 11% of anticipated reports had been filed.[48] While such issues are often associated with emerging economies, these early challenges show that institutional capacity is a barrier even in well-developed regulatory systems. In response, the European Commission proposed simplifications in February 2025, including exemptions for most small and medium-sized enterprises.[49]

2.3 Why CBAMs are not protectionist

The economic case for combining country specific carbon prices with a CBAM is clear but it faces resistance from some developing countries, which view it as protectionist and at odds with the principle of "common but differentiated responsibilities" set out in the Kyoto Protocol.[50,51] Russia has recently challenged the EU's CBAM at the World Trade Organisation as being "protectionist" in nature.[52] In reality, however, CBAMs are not inherently protectionist, can align with the principle of differentiated responsibilities, and represent one of the only viable tools for developed countries to decarbonise their hard-to-abate sectors while taking accountability for emissions embedded in imports.

2.3.1 Preservation of a level competitive playing field

If a country introduced a CBAM without introducing a carbon price on the relevant sectors, that would clearly be protectionist since it would improve the competitiveness of domestic industry relative to international competition – similar to a direct subsidy. But if a country imposes a carbon price and simultaneously introduces a CBAM at the same price level, it leaves the relative competitive position of domestic and foreign competitors unchanged.

Moreover, the explicitly desired objective of the EU's CBAM is not to raise tariff revenues, but instead to create an incentive for other countries to introduce carbon prices for internationally traded energy intensive sectors.

2.3.2 Common but differentiated responsibilities

The Kyoto Protocol established the principle of "common but differentiated responsibilities" by which all the participating countries shared the responsibility to reduce emissions, but with the pace of emission reductions varying between countries in line both with their level of current and past emissions per capita and their economic capacity to invest to achieve decarbonisation.

47 European Commission (2025), *Factsheet: Action Plan on Steel and Metals.*

48 Financial Times (2024) *World-first carbon border tax shows teething problems*. Available at https://www.ft.com/content/92b56c0b-663e-4820-90b1-533f1f36f08b. [Accessed May 2025].

49 Financial Times (2025), *Brussels to exempt most EU companies from carbon border tax*. Available at https://www.ft.com/content/c6102135-eefa-488f-81c2-4aa8eaf95644. [Accessed May 2025].

50 This principle was first formalised in the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and reaffirmed in the Paris Agreement (2015) (UNFCCC, 1992; Paris Agreement, 2015).

51 For example, under the Kyoto Protocol (1997), only developed countries had binding emission reduction targets, while developing nations had voluntary commitments.

52 WTO (2025), *European Union and its Member States - Carbon Border Adjustment Mechanism: Request for Consultations by the Russian Federation, Doc # 25-3328.*

The argument is therefore sometimes made that imposing a CBAM on carbon intensive imports from developing countries and thus encouraging/forcing them to accelerate the decarbonisation of their own heavy industrial sectors represents a contradiction of this principle. But this is not the case, since:

- The application of the principle should be and is reflected in the overall pace of emissions reduction to which different countries have committed, with, for instance, the EU and the UK adopting a net-zero by 2050 target, while India is committed to achieving net-zero emissions by 2070.
- This slower pace of targeted emissions reduction can be reflected in the pace of reduction in non-traded sectors of the economy without any need for international coordination. Thus, for instance if the UK decides to ban ICE passenger vehicle purchase from 2030, while India continues to allow ICE purchase until 2040 or later, this creates no competitive difficulties for the UK and reasonably reflects the fact that Indian consumers are on average less well able to absorb the currently still higher price of EVs than ICEs.
- By contrast, in relation to the internationally traded energy intensive sectors of the economy, permanently different carbon prices in different countries (unless offset by CBAMs) make it impossible for developed countries to achieve the faster pace of reduction towards net-zero emissions which developing countries have quite rightly demanded in international climate negotiations.

Moreover, the impact on developing country consumers of carbon pricing in the hard-to-abate sectors will be very small, thus:

- Demanding that passenger road transport decarbonised at the same rate in India as in Europe might impose a significant initial cost on Indian consumers.
- But accelerated decarbonisation of heavy industrial sectors in India and China will have a trivial impact on consumer living standards and negligible impact on attainable economic growth, particularly once allowing for the fact that developing countries which impose carbon prices will receive revenue streams which they can use to offset any effects.

2.3.3 Taking responsibility for imported consumption-based emissions

A CBAM is a crucial policy lever that enables richer, developed countries to bear greater responsibility for reducing emissions. It is also the only possible mechanism by which developed countries can take responsibility for imported “consumption-based emissions.”

As pointed out often in climate negotiations, many developed countries are indirectly responsible for more emissions than suggested by the production-based figures used in international climate agreements. This is because they are net-importers of carbon intensive goods from other countries, meaning they enjoy the consumption of those goods without being made responsible for their embedded emissions [Exhibit 2.3]. An argument is therefore often correctly made that developed countries should bear some responsibility for these imported “consumption-based emissions.”

Many developed countries are indirectly responsible for more emissions than production-based figures suggest

Greenhouse Gas Emissions (GHG) emissions in the UK 1990 to 2021

$MtCO_{2eq}$; latest data available from 2024 report includes data up to 2021

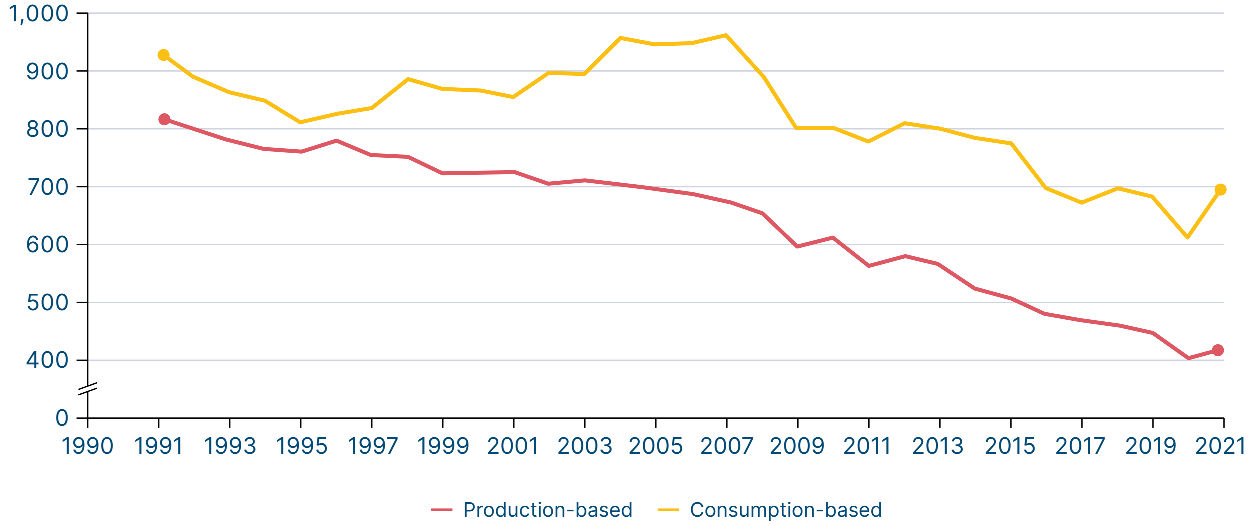


EXHIBIT 2.3

Note: Production emissions are defined as territorial emissions on the "Office for National Statistics" website, referring to "emissions that occur within the UK's borders and are used to track UK-wide progress towards international and domestic targets, such as net zero emissions by 2050.

Source: Waste and Resource Statistics, Defra, University of Leeds (2025). Available at https://www.gov.uk/government/statistics/uks-carbon-footprint.

Short of outright protectionism aimed at reducing trade volumes, the only effective way to cut these emissions is by decarbonising production in the exporting countries. For developed countries, a CBAM is the only viable tool to incentivise this shift – by encouraging exporting countries to adopt domestic carbon pricing.

A developed country that uses a domestic carbon price combined with a CBAM will raise the cost of carbon-intensive imports for its consumers. Any resulting carbon prices imposed by developing countries ensure that any resulting revenues accrue to the developing country government, not the developed government. In this way, a CBAM allows developed countries and their consumers to take responsibility for the costs of reducing imported consumption-based emissions.

2.4 Developing country response, international measurement standards and use of revenues

CBAMs have a clear role to play in the journey to net-zero. The EU is pioneering their implementation through its strengthened CBAM - crucial to progressing heavy industry decarbonisation in Europe. The ideal response from developing countries would be to introduce carbon prices for the heavy industry sectors of the economy, rising gradually towards European levels, and with the end result of a broadly common carbon price. Some steps in this direction are already occurring: the Chinese ETS has been extended to cover heavy industry sectors, and carbon prices have risen from the initial trivial levels, topping CN¥100 in 2024 (nearly $15) per tonne.[53,54]

Progress towards wider coverage of carbon pricing in heavy industry sectors could occur as a result of independent national decisions, but it would be desirable to create as much international consensus as possible. Three initiatives, which could be launched at COP30 in Brazil could help build that consensus:

53 BNEF (2024), *China carbon price tops 100 yuan for first time as rules tighten.*

54 Prices have since declined, falling below CN¥ 90 in February, mainly due to oversupply. See BNEF (2025), *APAC Carbon Radar: Prices Tumble as Asia Faces Oversupply.*

- International discussions, potentially managed by the WTO, to agree on global standards for measurement of carbon intensity of heavy industry production. Advanced work on standards is already in place providing a strong starting point for this discussion.[55]
- Technical assistance if needed for developing countries to develop the emissions data and institutional structures required for effective carbon pricing.[56]
- The allocation of some revenues that will accrue from the EU CBAM (for as long as other countries do not have equivalent carbon prices) to support climate finance flows to lower income countries.

2.5 Potential relocation of industry in a net-zero world

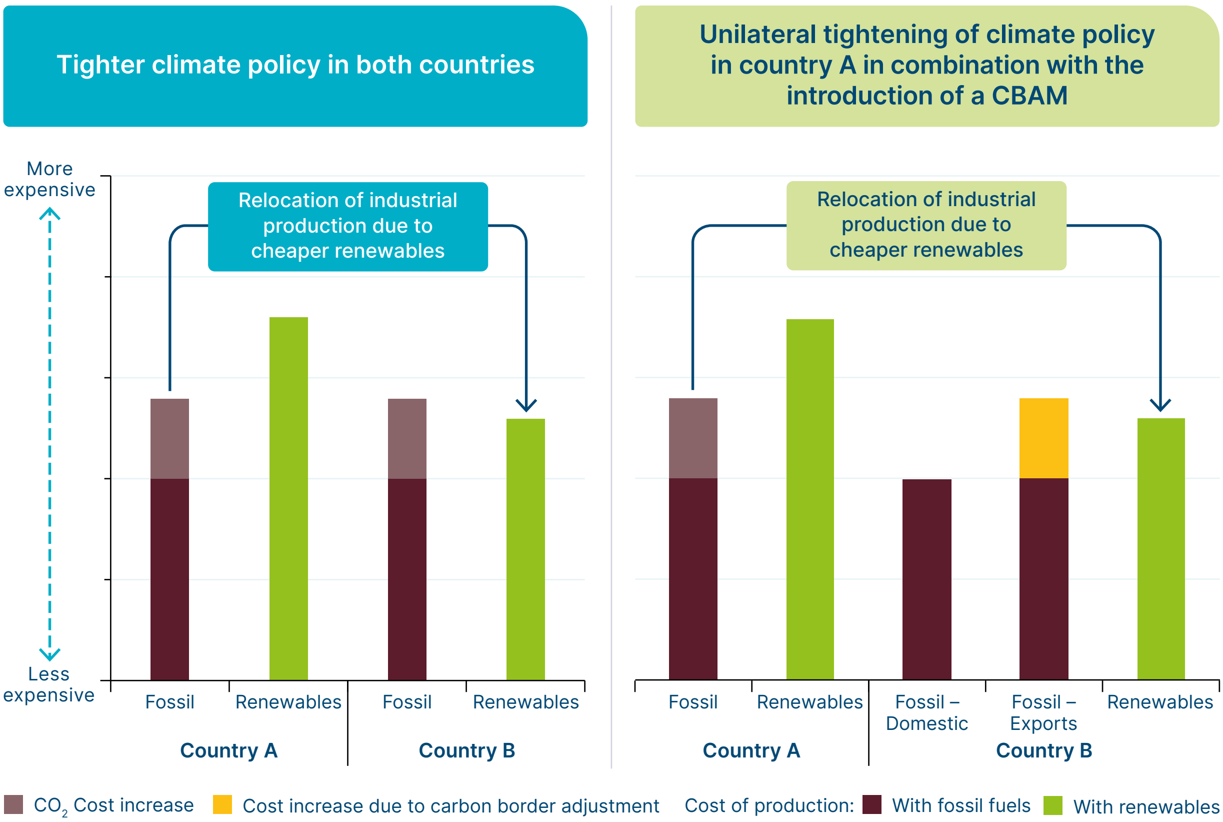
Having an internationally agreed carbon pricing for heavy industries – or having the combination of domestic carbon prices with a CBAM – will create a competitive level playing field for international trade. This will remove the danger that heavy industry relocates to avoid carbon prices, and that no true decarbonisation occurs.

But once that level playing field is in place, some heavy industry may move to new locations which are cost advantaged in zero emission production because of abundant renewable energy sources. For example:

EXHIBIT 2.4

Once carbon prices and adjustment mechanisms are in place, relocation of industry to areas with abundant natural resources may still occur

Cost of industrial production in two illustrative scenarios



Source: Energy Research & Social Science (2023), *The renewables pull effect: How regional differences in renewable energy costs could influence where industrial production is located in the future.*

55 See MPP (2025), *ITA Standards Map*, available at: https://ita.missionpossiblepartnership.org/ita-standards-map/. [Accessed 05/05/2025].

56 Programmes like the World Bank's Partnership for Market Implementation help developing countries build the infrastructure needed for effective carbon pricing. China also runs initiatives through its South-South Climate Cooperation Fund, supporting developing nations in climate actions, including carbon markets.

- Green hydrogen production costs, and thus green iron production costs, will be lowest in countries which enjoy low-cost renewable electricity supply. This will often be low-latitude developing countries endowed with large solar resources rather than high-latitude developed countries. In an upcoming report on power systems transformation, the ETC shows that total system cost in 2050 – including generation and balancing – could be approximately $30/MWh in India compared to $80/MWh in the UK.
- Sustainable aviation fuel production costs may be lowest in countries such as Brazil, which have both excellent solar and wind resources for low cost green hydrogen production and plentiful sources of low-cost and potentially sustainably-sourced bioresources.

Energy costs account for a significant share of total production expenses, and regional differences in energy prices could strongly influence locational decisions. For example costs for renewables and round the clock storage in Germany are approximately $130 per MWh for projects commencing in 2030, whereas equivalent costs in India are approximately $90 per MWh.[57] For established industry hubs in areas with high energy costs (e.g., Europe), relocating to regions with newly installed renewable generation could offer significant cost savings.

This will be even more relevant for industries requiring entirely new production processes to achieve climate neutrality. For example, production process for renewable energy-based hydrogen direct reduced iron (DRI) will require new direct reduction plants. In this case, locating the plants in geographies where hydrogen will be cheapest to produce will make the most sense. For countries with high local employment in steel making, this poses a substantial risk – though one possible scenario is that iron-making relocates to areas of cheapest energy input, but steel-making (including through electric arc furnaces) and finishing, which is less energy intensive but accounts for around 2/3 of overall jobs (and value added) remains in existing locations.

If, even once you have carbon prices that level the playing field, it is the case that developing countries are advantaged in zero-carbon production, there should not be any trade barriers to moving to these new locations. Carbon tariffs are not protectionist but countries standing in the way of natural relocation would be.

57 Systemiq analysis for the ETC; BNEF (2024), *Energy Storage System Cost Survey;* BNEF (2024), *Long duration energy storage cost survey.*

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