Energy Transitions Commission



# Global Trade and the Transition to Net Zero

Draft

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# INTRODUCTION

Global greenhouse gas emissions are rising rapidly, exceeding previous projections.[1] This coupled with the increasing frequency and severity of extreme weather events[2] highlight the urgent need for decisive climate action. A clean technology revolution is already underway, reducing the cost of decarbonization across multiple industries.

In some sectors, these low-carbon technologies have already reached cost parity with traditional alternatives, accelerating their deployment:

- The per-unit price for solar PV modules has fallen by 94% from 2011 to 2025 , and by 60% between 2020–2023 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]

In the some sectors, however, new clean technologies are expected to remain more expensive than fossil-based alternatives for decades to come – and in some cases, indefinitely. Particularly in so-called hard-to-abate sectors like long-distance transport (e.g. aviation and shipping) and heavy industry (e.g. steel, chemicals, and cement), zero-emission technologies are technically feasible but come with a significant green cost premium.

In its Energy Technology Perspectives 2024 report, the IEA highlights the vast economic opportunities in clean energy manufacturing: the global market for key clean energy technologies (e.g., solar PV, wind, electric vehicles, batteries, electrolysers, and heat pumps), reached over $700 billion in 2023, having nearly quadrupled since 2015. This is roughly equivalent to half of all global natural gas production that year. By 2035, this market could triple to be worth more than $2 trillion, rivaling the size of today's global crude oil market.

Global trade is currently experiencing major turbulence as a result of US President Donald Trump's imposition of global tariffs on the majority of US trading partners. Although these new tariffs are not directed specifically at low-carbon technologies, they add to previously-existing tariffs on low-carbon technologies and target Chinese manufacturing in particular. This is a particular concern as China has in the last decade emerged as the location of clean technology manufacturing.

While the concentration of manufacturing in China has enabled rapid cost reductions and accelerated renewable energy deployment around the world, it has also prompted both economic and security related concerns. In response, several countries have implemented measures such as tariffs and initiatives to onshore or nearshore clean tech manufacturing. For

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[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 BloombergNEF (2025), *Today's Photovoltaic Modules are Better as Well as Cheaper*.

[4] Note: 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 BloombergNEF (2024), *Wind Turbine Price Index 2H 2024: Still Aloft*.

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

[6] BloombergNEF (2023), *Long-term Electric Vehicle Outlook*.

[7] https://www.iea.org/commentaries/cheaper-electric-cars-the-key-to-unlocking-mass-market-adoption

instance, even before President Trump's new tariff measures, the United States had already imposed steep tariffs to protect domestic industries and reduce reliance on Chinese supply chains: 100% on Chinese-made electric vehicles, 50% on solar cells, and 25% on EV batteries, critical minerals, steel, and aluminum.[8] Similarly, the European Union has initiated investigations into Chinese subsidies for clean technology products, and imposed tariffs on electric vehicle imports.[9]

Alongside these tensions in the market for clean technologies, the appropriate approach to carbon pricing in the hard to abate sectors is also contentious. Since new technology application in these sectors faces a green cost premium, there is a strong case for carbon pricing to ensure decarbonization; and given the international nature[10] of these sectors, carbon prices imposed in one country alone can generate competitive disadvantage versus others. This is a pertinent global trade issue, the response to which is being pioneered by the European Union's carbon border adjustment mechanism (CBAM) to complement its emissions trading scheme, although this had generated opposition in some other countries.

In order for countries to maintain a rapid transition towards net-zero emissions by mid-century, and to maximize the economic opportunities presented by the global energy transition, two critical trade issues require strategic foresight and optimal policy development:

1. **The dominance of China in clean technology supply chains.**
2. **The role of carbon pricing and mechanisms for international coordination in the hard to abate sectors.**

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[8] https://www.pv-magazine.com/2024/09/16/u-s-increases-and-extends-clean-energy-import-tariffs-on-china/?utm_source=chatgpt.com

[9] https://www.ft.com/content/0ef28741-6194-4ee6-8f23-945415de7458?utm_source=chatgpt.com

[10] The international nature of sectors refer 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).

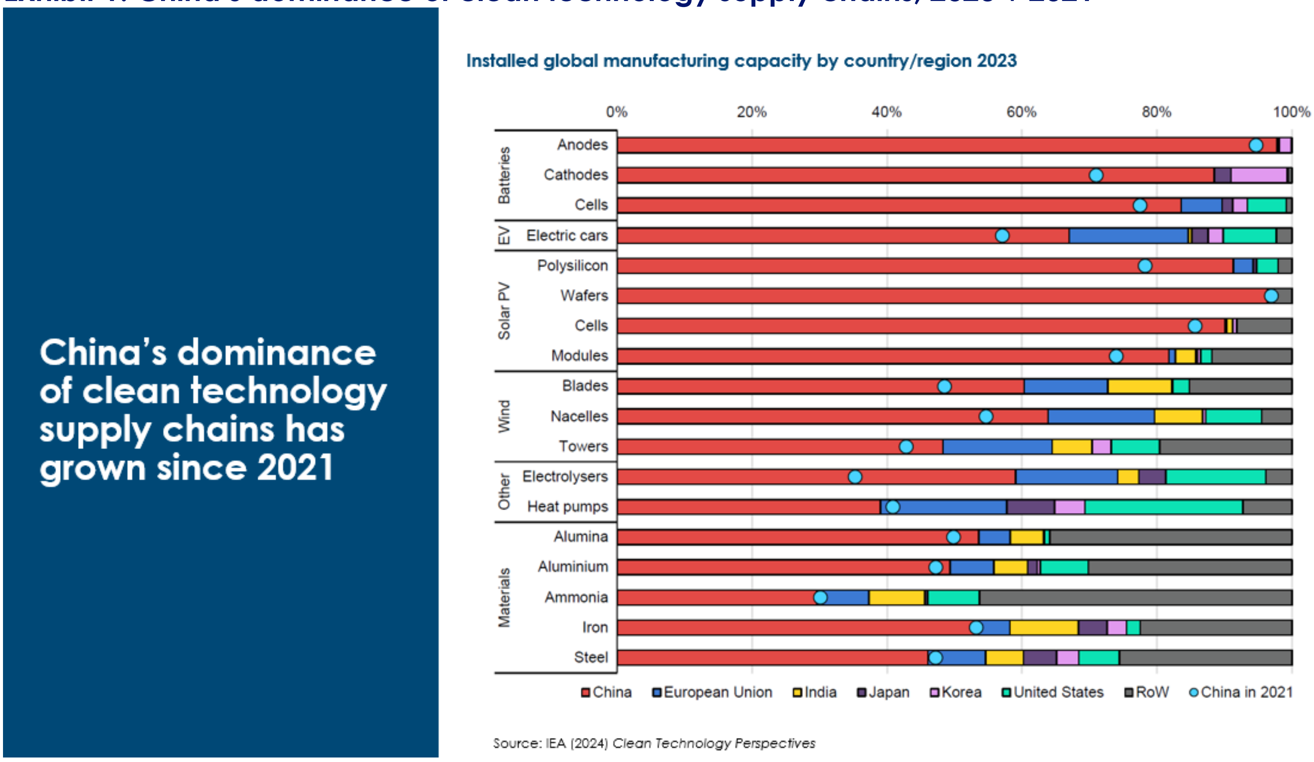
# 1 CHINA'S SUPPLY CHAIN DOMINANCE AND RESULTING TRADE ISSUES

China's dominant role in clean technologies reflects technological leadership, economies of scale, and learning curve effects. In an ideal world the cost reductions which it has achieved would be welcomed as enabling a lower cost transition to zero emissions economies across the world. But a combination of economic and security concerns means that many countries wish to reduce dependence on any one country and specifically on China. In this section we therefore assess the drivers if China's technological and cost leadership and suggest six principles to guide a balanced policy response.

## 1.1 KEY DRIVERS OF CHINA'S SUCCESS

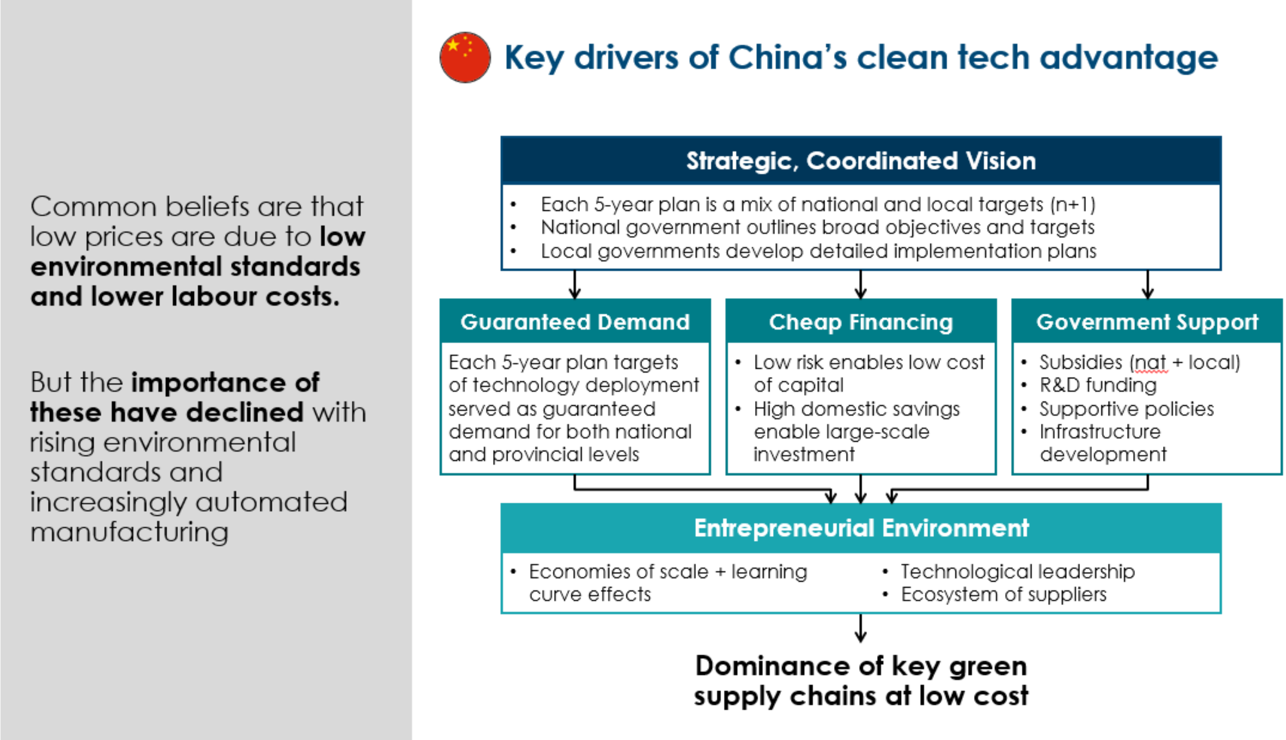
China has established itself as the dominant force in global clean energy manufacturing (Exhibit 1), accounting for an estimated 70% of total production across six key clean technologies. Its share of global manufacturing capacity for these technologies ranges from 40% to as much as 98%, depending on the component. Today, China produces more than 80% of the world's battery cells and solar PV modules, 65% of wind nacelles, 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 three years.

**Exhibit 1: China's dominance of clean technology supply chains, 2023 v 2021**




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.[11] Rather, there are five key factors driving the structural cost advantage which China has now achieved (see Exhibit 2).

**Exhibit 2: Key factors driving China's advantage**




- **Strategic, coordinated vision**: Each Five-Year Plan establishes 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 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 electric vehicles – positioning them as core pillars of China's clean technology strategy.[12]
- **Guaranteed demand:** Deployment targets create predictable local demand, providing a reliable market for new technologies. For example, in the 13$^{th}$ five-year plan (2016-2020), the government had a national target of 110 GW of installed solar capacity[13] while individual provinces also set their own targets. This guarantees manufacturers significant volumes of demand. Approximately 50% of solar PV and wind installations, and electric vehicle sales are in China itself.
- **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

[11] 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 year. Additionally in 2021, the Ministry of Ecology and Environment (MEE) launched a framework requiring large and medium-sized enterprises to disclose their greenhouse gas emissions, enhancing transparency and accountability in corporate environmental performance. (GFDC) Additionally, leading Chinese companies have committed to ambitious sustainability goals: LONGi, the worlds' leading PV module manufacturer has pledged to power all its operations with 100% renewable energy by 2028 (LONGi), reflecting the broader corporate shift towards greener practices.
[12] 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
[13] Note: China's 2020 solar target of 110GW, split into 105GW of solar PV and 5GW of concentrating solar power (CSP). Source: PVTech.org

low-cost financing, facilitating large-scale investment in innovation and manufacturing capacity.

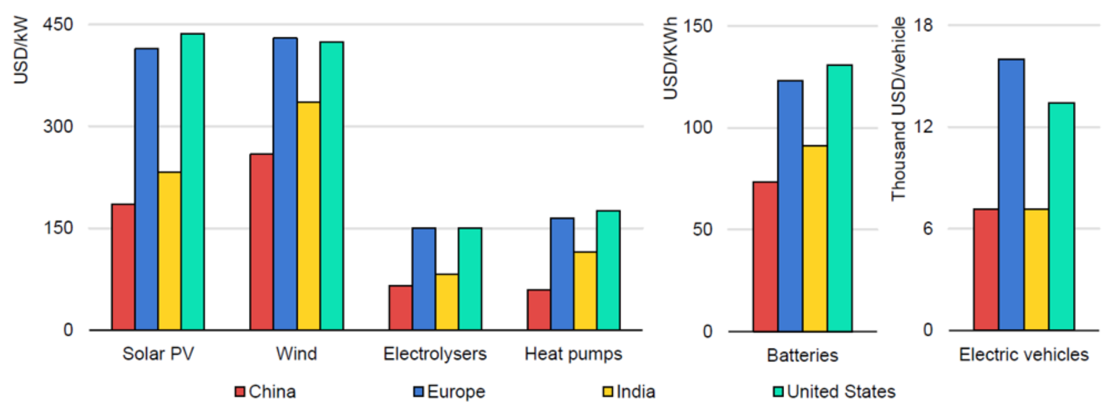
- **Government support** (including national and local subsidies, R&D funding, supportive policies, and investments in infrastructure): While these measures have been instrumental in scaling its clean technology industries, it is important to note that similar strategies have been employed by other countries as well, such as Germany's support for solar PV production in the 2000s.
- **Technological leadership,** reflecting a strong science research base, widespread technical skills, and strong entrepreneurial drive. China is now the leader in cutting edge technology development in batteries, EVs, solar panels, wind turbines and other clean products, as well as the lowest cost producer, providing China with a structural 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 3).

**Exhibit 3: Indicative capital costs for selected clean energy technologies by country, 2023**

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

**Indicative capital costs for selected clean energy technologies by country/region, 2023**




Source: IEA (2024) *Energy Technology Perspectives 2024*
*Notes: 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. Electrolysers and heat pumps include only the final assembly step. 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*

## 1.2 SIX PRINCIPLES FOR LOCAL SUPPLY CHAINS DEVELOPMENT

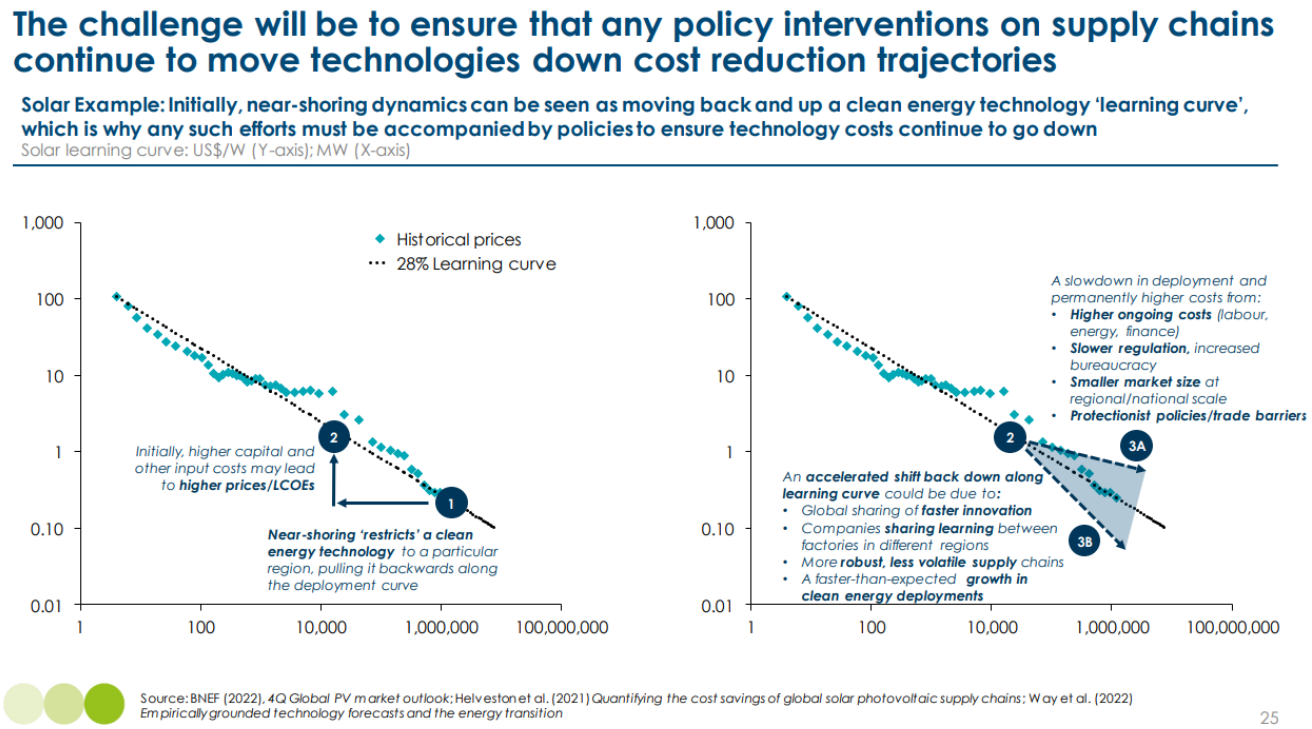
In an ideal world free of any geopolitical tensions or supply chain concerns, China's technological leadership and dramatic cost reductions would be welcomed as enabling a faster and cheaper energy transition towards zero emissions across the world. But multiple factors make many countries concerned about China's dominant role. These include concerns related to:

- **Concentrated and lengthy supply chains** in general. The past five years have made these vulnerabilities clear: COVID-19 lockdowns severely interrupted solar and semiconductor supply chains;[14,15] shipping congestion contributed to rising wind turbine prices;[16] and since 2021, the lead times for cables and large power transformers have nearly doubled, with wait times for certain specialized components (e.g., current cables commonly used in long-distance transmission) now exceeding five years.[17]

- **Implications of import dependency for "energy security,"** which in Europe increased greatly 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** 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.[18]

Countries therefore need to design clean tech supply chain strategies which address these concerns where legitimate, but which support continued and ideally accelerated cost reduction in key clean technologies (as demonstrated in Exhibit 4).

### Exhibit 4: Ensuring supply chain interventions continue to reduce transition costs




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

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.

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[14] International Solar Alliance (2023), Building Resilient Global Solar PV Supply Chains
[15] 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
[16] ETC (2024) Overcoming Turbulence in the Offshore Wind Sector
[17] IEA (2025) *Building the Future Transmission Grid*
[18] S&P Global Navigating supply chain resilience amid rising geopolitical risk (retrieved 9 May 2025)

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: it would deny countries the benefit of the technological progress and cost reduction which China has already achieved and exclude the stimulus to cost reduction and innovation which foreign competition can provide. Conversely, it is legitimate and rational for countries to seek to avoid a highly concentrated foreign supply chain, and to seek to build domestic employment and value added in technologies which will be central to future economic growth. This implies that:

- Government should focus on building domestic supply chains in sectors where they could be cost competitive and where there could be significant sustainable job creation.
- The aim should be for significant local content, but without excluding investment and trade flows. The EU Net Zero Industrial Act target that 40% of clean deployment needs should be met with local manufacturing by 2030[19] is a reasonable objective. Objectives embedded in India's Production Linked Incentives and the US Inflation Reduction Act (IRA) 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.

### 1.2.2 THINKING STRAIGHT ABOUT "SECURITY"

In trade related debates, the term "security" is used in a wide 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. 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 which drive 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.

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[19] European Commission (2024), *The Net Zero Industry Act explained*

- 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, Committee on Foreign Investment in the United States (CFIUS) has in the past imposed conditions on Chinese related battery companies which allow them to produce or sell battery cells or packs in the US while restricting their involvement in the provision of remotely controlled battery management software.[20]

### 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 versus 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, we see 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.
- **Electric vehicles,** 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 manufacture to reduce transport costs and aid just in time delivery. As a result there may be greater opportunity for well designed policy to ensure domestic EV and battery manufacture while avoiding a significant cost penalty.

### 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 electric vehicles, or solar panels)[21] and subsidies (e.g. tax breaks, government-backed loans, direct subsidies) to incentivize the development of low-carbon manufacturing and industry.

Both can play a role but should be deployed in ways which do not 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

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[20] To reference
[21] Brief overview of these at EU/US level

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.

- **World Trade Organisation (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. 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.[22]
- **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 revolutionized efficiency and quality in American auto plants.[23] 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.[24]
- **When the gap in knowledge, skills, or cost competitiveness is large, catching up without leveraging the expertise of industry leaders 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.[25] 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.[26]

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

[22] http://smmt.co.uk/wp-content/uploads/2024/11/SMMT-Motor-Industry-Facts-2024-August.pdf
[23] Mishina, Kazuhiro. "Toyota Motor Manufacturing, U.S.A., Inc." Harvard Business School Case 693-019, September 1992. (Revised September 1995.)
[24] https://intimedia.id/read/indonesias-electronics-industry-thrives-the-role-of-pt-samsung-electronics-indonesia-in-driving-export-growth-and-domestic-manufacturing
[25] https://www.thecorporategovernanceinstitute.com/insights/case-studies/what-went-wrong-at-britishvolt
[26] https://www.businessinsider.com/northvolt-files-bankruptcy-ev-battery-maker-sweden-goldman-blackrock-vw-2025-3

to facilitate technology transfer, allowing Chinese firms to gain operational expertise and technical knowledge from more advanced foreign manufacturers.

- Similarly, existing funding under the U.S. 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[27]. Electric vehicles – including two-, three-, and four-wheelers – are also approaching cost parity with internal combustion engine (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*.[28] Across the world, and in particular in China, India, and Europe,[29] clean investment has been rising rapidly and broadly in line with the pace required to limit global warming to well below 2°C.[30] But investment growth in lower middle- and low-income countries has been far too slow.

As reinforced in the global finance agreement at COP29, there is therefore a significant opportunity and need for those developed countries which are still committed to the Paris climate process – plus China – to work together to scale up financial flows to lower middle- and low-income countries, enabling accelerated electrification and clean electricity supply. 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.

[27] See forthcoming ETC (2025) on global power systems (exact title TBC)
[28] ETC (2023), Financing the Transition: How to Make the Money Flow for a Net-Zero Economy
[29] Until recently, this group also included the US
[30] 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 Gt of $CO_2$ emissions per year, or around 30% of the global energy-related total.[31]

These sectors are either inherently international (as with aviation and shipping) or deeply embedded in globally traded markets. 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 PREMIUM, AND THE NEED FOR CARBON PRICING

Hard-to-abate sectors are those where the technologies and methodologies to decarbonize these sectors do exist but have not yet reached, and may never reach, price parity with their more traditional, carbon-intensive counterparts. These sectors are characterized 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, which produces carbon dioxide as a byproduct of the chemical processes involved in cement manufacturing, will always require this carbon dioxide to be captured as part of its decarbonization strategy. This by extension will always result in higher costs compared to traditional methods.
- Similarly, sustainable aviation fuel (SAF) faces significant challenges in achieving cost parity with traditional fuels due to factors like the feedstocks used, the complex production processes involved, and the current scale limitations on production.
- Steel decarbonization is highly dependent on the cost decline of hydrogen, but could reach price parity in the mid-2030s.[32]

As a result, hard-to-abate sectors will likely require continued support and targeted policy interventions to drive down costs and facilitate their transition to more sustainable practices.

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[31] MPP (2024) *MPP Heavy Industry Tracker*
[32] MPP Steel: https://www.missionpossiblepartnership.org/action-sectors/steel/

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. For instance, as shown in Exhibit 5, the cost impact at the consumer level can be negligible, such as less than $0.01 additional for a soda made with green plastics or $0.03 more for a kilogram of imported fuel using green shipping methods. In contrast, the cost impact at the intermediate product level could be much more significant, with prices for green plastics potentially increasing by over 50% or the cost of bulk shipping rising by up to 110%.

**Exhibit 5: Impact of green premium on final and intermediate product costs**

| | | Impact on final product cost<br>US$ / % price increase | | Impact on intermediate product cost<br>US$ / % 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 | +$40-80 on a 6,500-km economy flight | +10-20% | +$0.3-0.6 per liter of jet fuel equivalent | +50-100% |

*Source: ETC (2018) Making Mission Possible*

This discrepancy in price impacts highlights a critical challenge: decarbonization at the business level will be nearly impossible without mechanisms like carbon pricing or equivalent regulations to internalize the costs of green technologies.[33] Without a carbon price, businesses may struggle to make the necessary investments in sustainable practices. Carbon prices are therefore needed to drive decarbonization of these hard-to-abate sectors. These prices will have minimal impact on end consumers over the long term, ensuring the broader transition remains affordable and sustainable.

## 2.2 THE INTERNATIONAL COORDINATION CHALLENGE AND THE ROLE FOR CBAM

Given the international nature of several hard-to-abate sectors, achieving effective decarbonization 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 decarbonize 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 ton on emissions above a defined intensity threshold

[33] Some companies like Fortescue and PepsiCo have taken steps to decarbonize without a carbon price, but this is largely the exception

which falls gradually over time.[34] While the scheme is estimated to be insufficiently demanding to reduce emissions at the pace defined by the IMO's previously agreed targets,[35] 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[36].

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.

The European Union has the world's largest and longest running carbon market, though carbon pricing schemes are now in place across 53 countries covering over 20% of global emissions[37]. The EU initially sought to address the international competitiveness challenge by providing heavy industry sectors with free allowances within its emissions trading scheme (EU-ETS). But this greatly reduced the incentive for decarbonisation. The EU is therefore now committed to removing the free allowances and instead introducing a carbon border adjustment mechanism (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.

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.[38] In March 2025 the European Union 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*

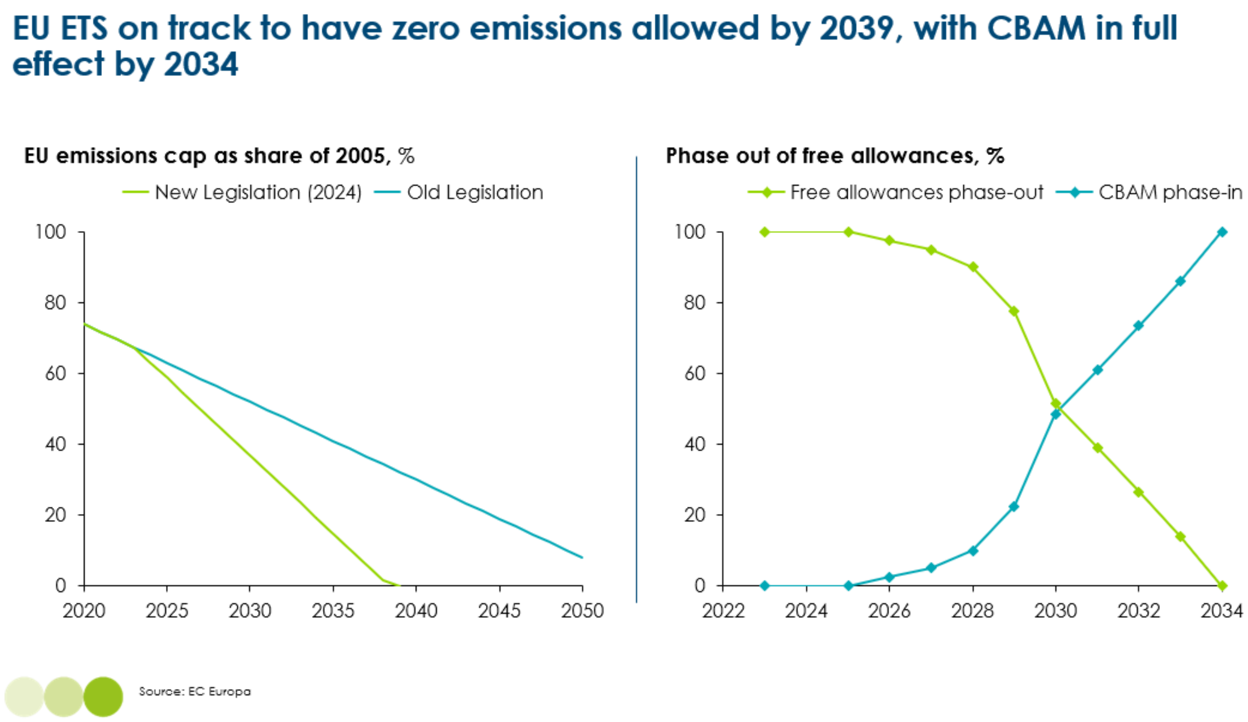
*The European Union's Carbon Border Adjustment Mechanism (EU CBAM) was formally adopted in April 2023 as part of the European Union's broader Fit for 55 climate package and was designed to complement the EU Emissions Trading Scheme (ETS), which was established in 2005. The price in the EU ETS is currently around €70/t$CO_2$ ($80/t$CO_2$[39]) – a price high enough to incentivize decarbonization 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, aluminum, fertilizers, hydrogen, and electricity.*

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

[34] Reuters (2025), *UN shipping agency strikes deal on fuel emissions, CO2 fees*
[35] Lloyd's List (2025) *MEPC83: A faltering step towards net zero*
[36] A reason for many other countries abstaining from the vote was because they didn't see the measure as ambitious enough
[37] World Bank (2025) *Carbon Pricing Dashboard*, available at: https://carbonpricingdashboard.worldbank.org/
[38] MPP (2024) *MPP Heavy Industry Tracker*
[39] Ember Energy (May 2025) *European electricity prices and costs*

- ***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 6).*

**Exhibit 6: Phase out of free ETS allowances between 2026 and 2034**




*Domestic stakeholders have already identified areas that could be strengthened, as there is a real concern that some companies may not be able to stay competitive long enough to benefit from the protection the EU CBAM will eventually offer:*

- ***Stronger support for domestic industry:*** *In anticipation of the removal of free EU allowances, and increased carbon price payments, EU industrial companies are pursuing investments in low-carbon technologies, but in many cases struggling to make the business models work. Stronger policy support – such as government-backed offtake agreements (e.g., Germany's "carbon contracts for difference"), or financial support in the form of direct subsidies or low-interest loans from institutions like the European Investment Bank (EIB) – could help preserve domestic industry during the interim phase.*
- ***Export rebates for green goods:*** *While the EU CBAM ensures equal treatment of imports and domestic production, European goods could still face a competitive disadvantage exporting to markets without similar carbon pricing mechanisms. Export rebates for green products would help mitigate this imbalance, ensuring the long-term competitiveness of EU industries and supporting the global shift towards low-carbon production.*
- ***Emissions calculation and greenwashing risks:*** *Emissions are currently reported at the individual plant level, but firms with multiple plants may be able to sell into the EU from the accredited low-carbon installation, exporting elsewhere with other higher emitting plants. Thus, there is a key question as to whether emissions should be measured on a site-specific basis, account for all company sites, or averaged across all production facilities within a geography. Ultimately wider carbon pricing is likely to mitigate this risk.*

*The implementation of the EU's Steel and Metals Action Plan (2025) is expected to mitigate most of these domestic risks, including extending CBAM coverage to a broader group of* *downstream products.[40]*

## 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.[41,42] 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 decarbonize 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.

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 European Union 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

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[40] EC Europa (2025) Factsheet: Action Plan on Steel and Metals

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

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

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:

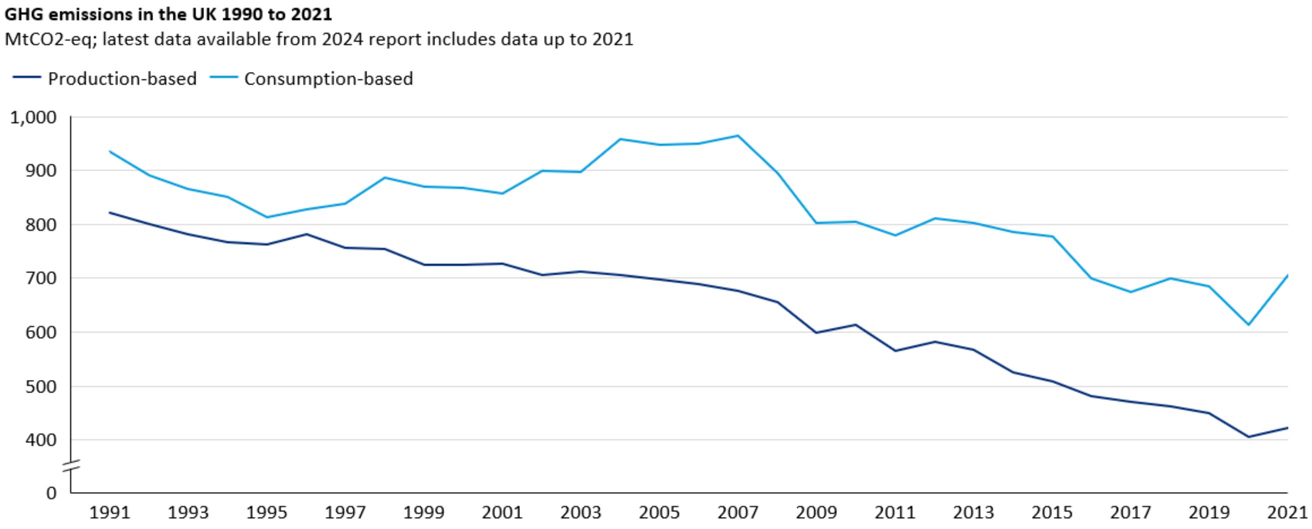
- Demanding that passenger road transport decarbonised at the same rate in India as in Europe might impose a significant initial cost on Indian consumers
- But accelerated decarbonisation of heavy industrial sectors in India and China will have a trivial impact on consumer living standards and negligible 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.

Rather than diverging from the principle that richer, developed countries should bear greater responsibility for reducing emissions, a CBAM is a crucial policy lever that enables them to do so. It is also the only possible mechanism by which developed countries can take responsibility for imported "consumption-based emissions."

As has often been pointed out 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 (see Exhibit 7). Some therefore assert, and with merit, that developed countries should bear some responsibility for these imported "consumption-based emissions."

**Exhibit 7: Production and consumption-based emissions for the UK 1990 to 2021**




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: Office for National Statistics, 2024*

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 incentivize 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 by introducing its strengthened CBAM and cannot reverse course without seriously undermining progress towards heavy industry decarbonisation in Europe. The ideal response from developing countries would be for them to introduce carbon prices for the heavy industry sectors of the economy, rising gradually towards European levels, which in term may form some sort of global parity. Some steps in this direction are already occurring: the Chinese emissions trading scheme has been extended to cover heavy industry sectors, and carbon prices have risen from the initial trivial levels, topping 100 CNY in 2024 (nearly 15 USD) per tonne.[43,44]

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 COP 30 in Brazil could help build that consensus:

- International discussions, potentially managed by the WTO, to agree global standards for the measurement of the carbon intensity of heavy industry production. Advanced work on standards is already in place providing a strong starting point for this discussion.[45]
- Technical assistance if needed for developing countries to develop the emissions data and institutional structures required for effective carbon pricing.[46]
- The allocation of some of the revenues which 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

Either internationally agreed carbon pricing for heavy industry, or the combination of CBAMs, led by the EU, 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.

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

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[43] Bloomberg UK (2024), *China carbon price tops 100 yuan for first time as rules tighten*

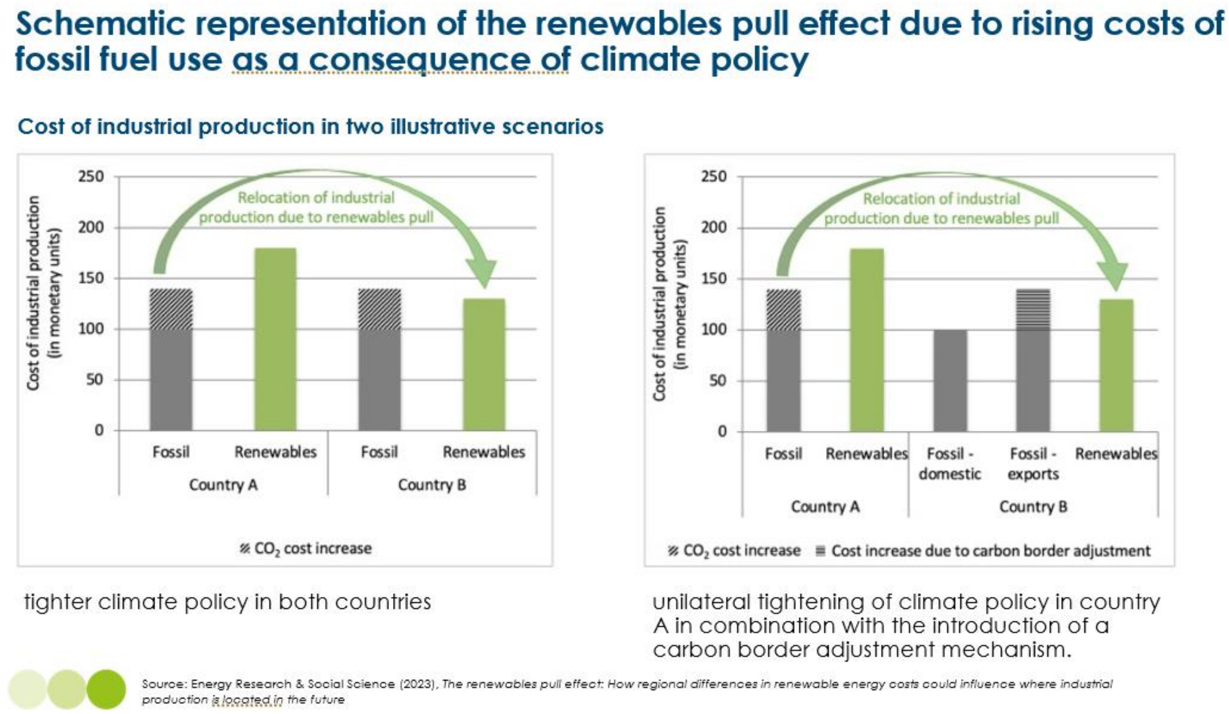
[44] Note: Prices have since declined, falling below 90 in February, mainly due to oversupply; BNEF (2025) APAC Carbon Radar: Prices Tumble as Asia Faces Oversupply

[45] See Mission Possible Partnership (2025) *ITA Standards Map,* available at: https://ita.missionpossiblepartnership.org/ita-standards-map/

[46] Programs 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.

renewables and round the clock storage in Germany are approximately $130/MWh for projects commencing in 2030, whereas equivalent costs in India are approximately $90/MWh.[47] 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.

**Exhibit 8: Illustrative view of how renewable-rich geographies attract industry**




This will be even more relevant for industries requiring entirely new production processes to achieve climate neutrality. For example, renewable energy- based hydrogen Direct Reduced Iron (DRI), production processes 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.

[47] ETC (2025) leveraging BNEF (2024) Energy Storage System Cost Survey; BNEF (2024) Long duration energy storage cost survey