China and the European Union's Carbon Border Adjustment Mechanism:

Cultivating Mutual Benefits for the EU and China

CHRIS BUSCH (EI), HU MIN (IFS) AND CHEN MEIAN (iGDP)

APRIL 2022

SUMMARY

This report examines the European Union's proposed carbon border adjustment mechanism (CBAM) with a focus on implications for China. It provides policy recommendations for both the EU and China to reduce tensions the proposal has generated, allowing for productive cooperation on climate.

The CBAM will assess a fee on certain imports sold in the EU based on the products' emissions intensity. A pilot phase is expected to begin in 2023, with imposition of border fees beginning in 2026.

The CBAM aims to directly account for carbon cost differences, leveling competition for domestic and international producers, addressing domestic competitiveness concerns, and counteracting leakage—the unintended shifting of emissions to jurisdictions with weaker policies. Previously, emissions trading system (ETS) design almost invariably distributed free allowances to cushion industries facing international trade pressure.[1] However, policymakers now have a better understanding of the drawbacks of this approach, leading the EU to view the CBAM as an essential ETS improvement, delivering a higher-quality price signal and better leakage protection.

[1] California's ETS has included a border adjustment for imported electricity from the program's inception in 2013.

ENERGY INNOVATION POLICY & TECHNOLOGY LLC

IFS INSTITUTE OF FINANCE AND SUSTAINABILITY

绿色创新发展中心 Innovative Green Development Program

The limited number of CBAM-covered products—just five initially—means almost all of China's EU exports will be untouched. Chinese exports of CBAM-covered products are almost entirely in aluminum, iron, or steel production. Even in these sectors, several moderating factors will make impacts manageable.

To expand the upsides and limit negative effects due to the CBAM, China should expeditiously move forward with expanding coverage and strengthening its national carbon ETS (CN ETS). This will lower the emissions intensity of Chinese industry, reducing exposure to potential border adjustment fees. A stronger CN ETS will also accelerate domestic innovation and improve the competitiveness of Chinese enterprises in an increasingly carbon-constrained world. The alignment between decarbonization policies and China's broader economic strategy is underappreciated by some members of the State Council, necessitating a parallel communication effort to build support for more ambitious policies.

For the EU, successful CBAM implementation will maximize emissions reductions and minimize international backlash. Rather than alienating partners, the EU wants trade partners to follow its lead in reducing emissions. To this end, we urge the EU to directly counter unfairness complaints lodged by developing countries by dedicating a meaningful share of CBAM fees to compliance assistance, with the most generous support going to the lowest-income countries. In addition, the CBAM must evolve to account for decarbonization policies other than those setting a directly observable carbon price.

This report develops recommendations for the EU and China, aiming to reduce tensions and achieve national goals. Actions with mutually beneficial outcomes would positively affect EU-China cooperation, which will be necessary if global efforts to limit climate change are to succeed.

Table of Contents

INTRODUCTION

This report outlines the EU's proposed CBAM design along with the likely implications for China, providing policy recommendations for both China and the EU to support mutually beneficial outcomes.

The CBAM will assess a fee on certain imports sold in the EU based on the products' emissions intensity. A pilot phase is expected to begin in 2023, with imposition of border fees beginning in 2026. The CBAM aims to directly account for carbon cost differences, leveling competition for domestic and international producers, addressing domestic competitiveness concerns, and counteracting leakage—the unintended shifting of emissions to jurisdictions with less stringent emissions standards.

Overall effects of the CBAM on China's exports to the EU are expected to be moderate because of the small number of industries to be covered. Even in CBAM-covered sectors, Chinese enterprises will face manageable impacts. There are also economic advantages for China, uninvited though they may be, such as alignment with China's economic strategy, which emphasizes boosting domestic technology innovation and expanding higher-value manufacturing.

Positive effects for China could be magnified by more rapidly expanding and strengthening the CN ETS alongside greater investments in decarbonization. The EU could also enhance CBAM implementation by providing equity assistance and accounting for climate policies other than those establishing observable carbon prices. Though it will be several years before the shape of the EU CBAM is finally determined and implementation begins, it represents a new chapter in global climate policy.

The next two sections explain carbon border adjustment theory and the proposed design of the EU CBAM. The report then examines the expected impacts on China, providing insights on moderating forces and a review of key quantitative studies. The last section presents policy recommendations for China and the EU. Appendix A provides a glossary, while Appendix B delves more deeply into the results and methods of the quantitative studies summarized earlier.

CARBON BORDER ADJUSTMENTS

Border adjustments are used in trade policy to ensure consumers of a good or service pay the same tax regardless of whether the good or service is imported or produced domestically. A border adjustment typically works by applying taxes to imports and rebates to exports. Export rebates are not expected under the CBAM, however, because of legal risk under World Trade Organization rules.

Until now, ETS and other climate policy design has relied on free allowance distribution in industries facing international trade pressure to address leakage and competitiveness concerns—the perceived risk that carbon allowance costs will make domestic industries uncompetitive relative to producers in jurisdictions without emissions standards.[ii] Free distribution does counter added costs, but there is growing evidence that border adjustments are a better policy tool.

For instance, it is now clear that free allocation provides a type of subsidy, increasing the incentive for production in a given industry. In effect, free allocation creates subsidies encouraging greater production, sending a suboptimal price signal. An EU-commissioned study concludes free allocation inevitably weakens the price signal for long-term, large investments, stating: “Summarizing the findings in literature, it can be concluded that free allocation does distort the CO_2 price signal to some extent, despite the theoretical independence between allocation method and abatement behavior.”[1]

CBAMs offer better leakage protection because of the declining number of allowances. As caps ratchet down, a best practice in ETS design is to reduce free allocation to industry proportionately. This prompts industry alarms about leakage and competitiveness for which higher carbon prices over time are no match. Increasing allowance scarcity on the way to net-zero carbon emissions creates an inherent, growing structural tension with the practice of free allocation. Carbon border adjustments provide a strategy for addressing industry leakage concerns while at the same time enabling a level playing field and more efficient pricing.

Industries know their customers, supply chains, and factories better than regulators ever can. This can make it challenging to refute even inflated leakage claims.[iii] Because carbon border adjustments can be readily communicated, they provide policymakers with an effective response to pressure from industry.

[ii] Leakage and competitiveness and the related concept of emissions-intensive, trade-exposed industries are explored further in the second report in this series.

[iii] California initially identified low-, medium-, and high-leakage risk categories as part of a plan to ratchet down free allocation at a rate faster than annual cap reductions for low- and medium-risk enterprises. This approach was abandoned in the negotiations

Finally, by better leveling the playing field between imported and domestic goods, border carbon adjustments offer more effective leakage and competitiveness protection, which in turn can reduce political resistance, smoothing the path for increasingly strong policies.

In sum, compared to free allocation, carbon border adjustments send a higher-quality price signal and provide better leakage protection, while also offering advantages for engaging with stakeholders, building support, and catalyzing stronger policy.

THE EU PROPOSAL

The EU officially detailed its proposed CBAM design in July 2021 as part of its package of policies for achieving a 55 percent reduction below 1990 emissions (Fit for 55).[2] The EU CBAM will assess a fee on certain products sold in the EU based on the products' emissions intensity. Aspects of the policy could change before it is formally adopted. Still, the initial shape of the CBAM is unlikely to radically depart from the proposed outlines.

The EU plans to initiate reporting requirements in 2023 and begin charging border adjustment fees in 2026, gradually phasing in fees over the next decade. Meanwhile, free allocation will be reduced by 10 percent in 2026 and by an additional 10 percent each year thereafter. Such a schedule implies a complete drawdown in free allowance support after 2035.[3]

The scope of the EU CBAM will be limited at the outset in terms of both covered emissions and sectors, initially covering five industries with homogenous products and high leakage risk. Sectors proposed for coverage include iron and steel (a single category), aluminum, cement, fertilizer, and electrical energy. At first, the EU CBAM is also slated to exclusively cover direct emissions, i.e., emissions from on-site sources. Indirect emissions, such as those associated with grid-connected electricity use, could be included in the future.

Calculation of the CBAM fee can be boiled down to three components and expressed for a generic product as an equation:

$$\text{CBAM fee} = \text{emissions intensity} \times \text{product} \times \text{carbon cost}$$

"Emissions intensity" stands for carbon dioxide equivalent emitted per unit of production. "Product" refers to the quantity of goods imported into the EU. "Carbon cost" is calculated as the difference in carbon cost between the EU and the importer's home country. If this difference is negative, meaning there is a higher carbon cost for producers in the trading market, or if it is zero, the program would not be expected to impose any fee.

Although European industry has argued EU exporters in CBAM-covered sectors should receive refunds to compensate for their carbon costs, such subsidies would greatly increase legal risks under international trade agreements and are not included in the EU's proposal.[4]

The EU's policy is expected to offer two options for CBAM compliance. The first option involves a detailed accounting at the plant level, mirroring the approach required of EU producers. The second option is to select the default value for products from a given country. This approach is a best practice in the few

---

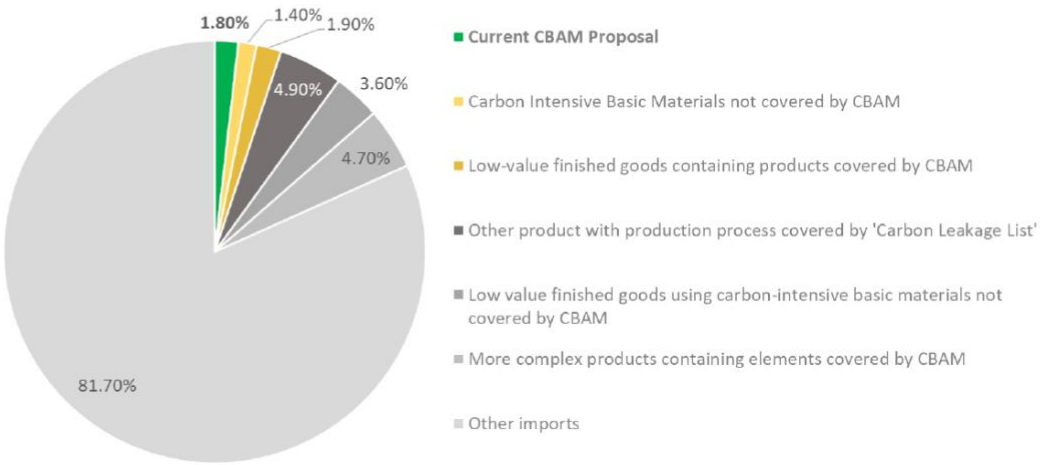
that led to extending authority for California's ETS through 2030. The state's retreat is evidence of the typical challenges regulators face in withdrawing free allocation support.

examples of carbon border adjustments—for example, it is used for electricity imports in California's cap-and-trade program.

CHINA'S CBAM-COVERED TRADE DWARFED BY OVERALL EU EXPORTS

The five sectors proposed for initial coverage under the CBAM represent a small fraction of China's total EU exports. Specifically, the best research into this issue indicates CBAM-covered products make up 1.8 percent of China's total EU exports, as illustrated in Figure 1.

Figure 1. CBAM-covered goods make up only about 1.8% of China's total EU exports[5]

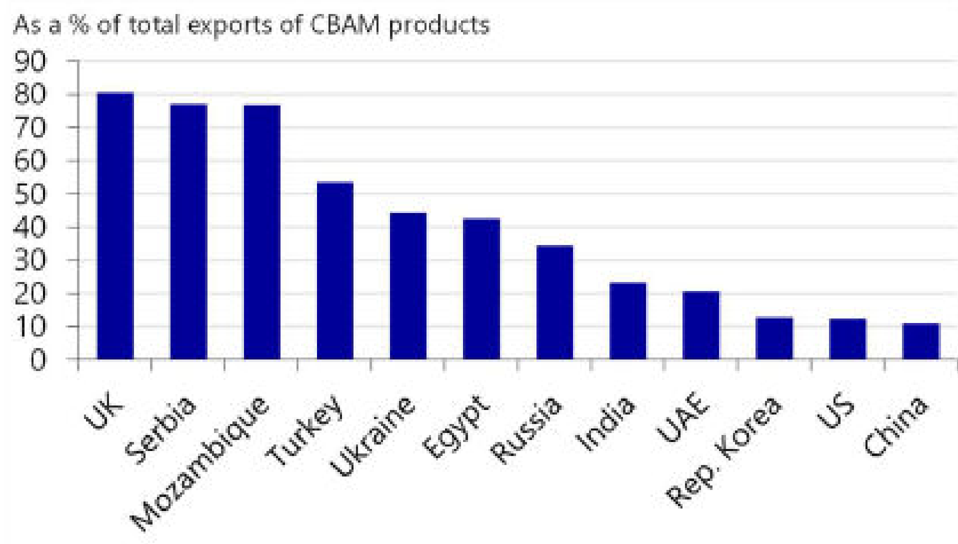


In 2020, exports of two categories—aluminum and the combined category of iron and steel—represented 99 percent of China's exports of CBAM-covered products. These exports brought in €6.2 billion in 2019, compared to €75 million for the third-most valuable sector, fertilizers.[6]

Though China is one of the largest exporters to the EU, China's CBAM-covered exports to the EU are dwarfed by its exports from these sectors to the rest of the world. Of China's aluminum exports, only 9 percent go to the EU, while 91 percent are destined for non-EU countries. Similarly, while 8 percent of China's iron and steel exports go to the EU, 92 percent are directed to non-EU countries.[7]

Figure 2 illustrates China's comparatively low dependence on EU exports in these sectors. Eleven countries, including the United States, are more dependent on trade with the EU, as measured by percentage of CBAM-covered exports out of total exports of those products. China is still a top steel and aluminum supplier to the EU. Its total CBAM-covered exports to the EU are the third largest globally in absolute terms, meaning a tiny fraction of China's trade is still larger in revenue earned than for all countries but Russian and Turkey in a European study of 2019 trade data.[8]

Figure 2. CBAM product exports to EU as a percentage of total global exports of those products[9]



FACTORS MODERATING LEAKAGE RISK FOR CHINA

The significant, existing emissions intensity and carbon price differentials between the EU and China could be taken to imply that China will suffer severe effects from the EU CBAM, but at least three factors will moderate risk for affected Chinese enterprises: cost pass-through effects, resource shuffling options, and policy practicalities.

A subtle but crucial moderating force is the economic phenomenon known as carbon price cost pass-through: the ability of businesses to pass along higher costs of production to consumers in some situations. Currently, EU firms in CBAM-covered sectors are price takers. As a result, EU firms are unable to pass through the price of carbon to their customers without losing market share, shielding EU retail prices from carbon price costs for EITE industries.

CBAM implementation will change this dynamic, allowing carbon cost pass-through to retail prices. As a result, all producers of CBAM-covered goods—both EU producers and exporters to the EU—will be able to raise prices to incorporate the cost of carbon pollution for products sold in the EU. Therefore, increased revenue from higher prices for CBAM-covered goods will partly counterbalance border fees, as illustrated by quantitative results discussed in the next section.[iv]

Another moderating force, resource shuffling, occurs through changes to energy accounting or trade flows, resulting in lower carbon intensity for export production but a largely unchanged energy system. Plainly, resource shuffling frustrates the objective of emissions reductions and is to be discouraged. The difficulty of tracking products and energy flows in other countries and economic incentives encouraging resource shuffling mean policy design cannot eliminate it completely.

[iv] The gains for producers due to higher prices will outweigh losses due to the suppression in consumer demand also induced by price increases in European domestic markets.

Policy practicalities are a final force moderating leakage risk in China's CBAM-covered industries. First, the relatively gradual introduction of the EU CBAM means its full effect will not be realized until the mid-2030s, assuming the proposed implementation schedule is adopted. Second, China is already committed to lowering its carbon intensity, which could reduce or ultimately eliminate fees assessed on Chinese exports under the EU CBAM.

China released a detailed peaking plan before the international climate conference in Glasgow, Scotland. At the conference itself, the U.S. and China each committed to deepening climate cooperation and ambition. A full accounting of China's carbon commitments and plans is beyond the scope of this report, but they point to continued improvements in Chinese industry's emissions intensity.

QUANTIFYING EXPECTED IMPACTS

The E3G/Sandbag report *A Storm in a Teacup* offers the best insights into expected EU CBAM effects for China because its modeling is the most realistic. The work is one of the few to have been completed after the EU publicly released its preferred EU CBAM design, leading to strong alignment.

When evaluating research, it is important to understand a handful of such key modeling factors. Assumptions about future carbon price differences between the EU and China is another crucial variable to consider when evaluating a study's methodological soundness. Appendix B further discusses key input assumptions in *A Storm in a Teacup*, featured in this section, and other relevant research.

Whether or not cost pass-through effects are reflected is a crucial assumption, as *A Storm in a Teacup* illuminates. The report presents two perspectives on cost. "Direct cost" is the unadjusted border adjustment fee enterprises exporting to the EU would face, i.e., without carbon price pass-through. "Net cost" is the effect on exporter revenue accounting for carbon price pass-through, indirectly raising EU consumer prices and increasing exporter revenue.

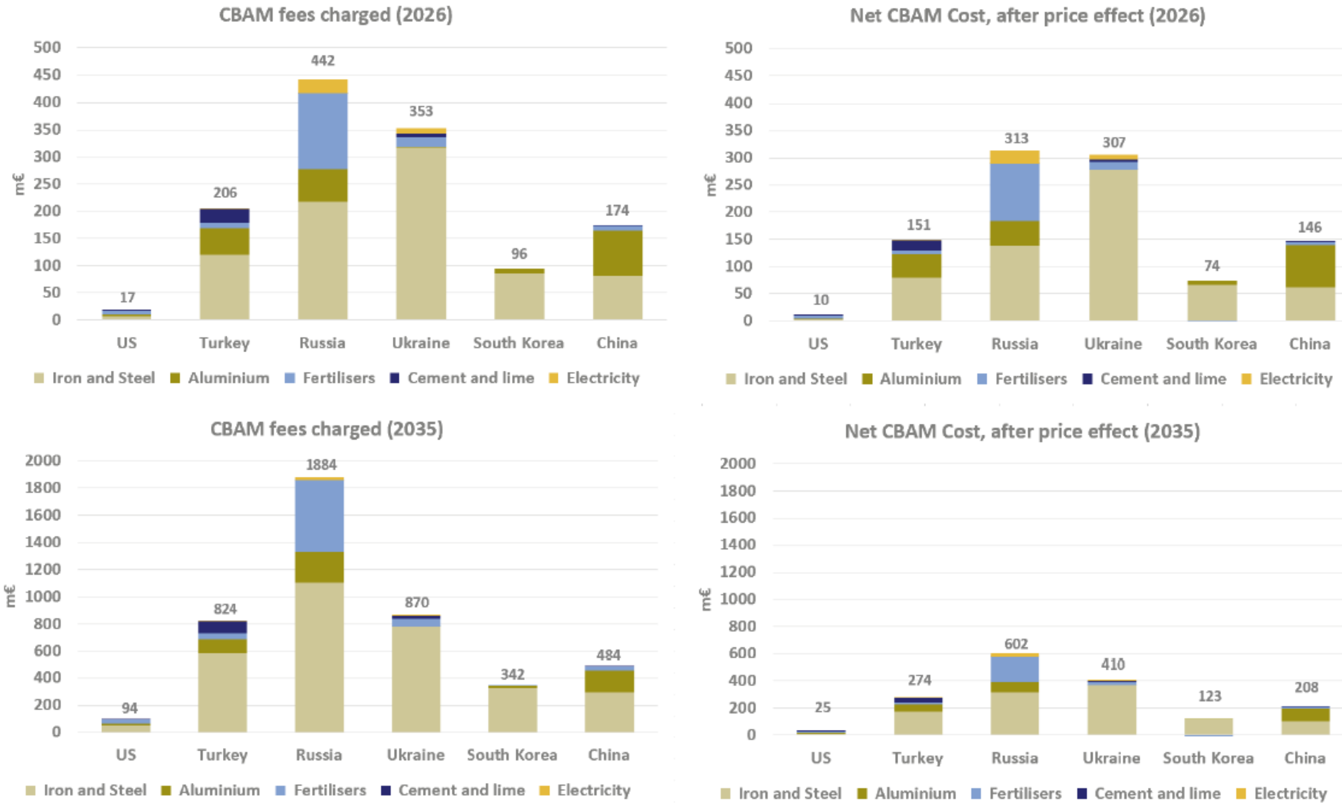
A Storm in a Teacup finds the EU CBAM will introduce net costs for China in the range of €150 to €200 million, representing 0.04 to 0.06 percent of China's total EU exports. The lower bound represents the first year of implementation in 2026. The upper bound captures full implementation after a 10-year phase-in, assumed to occur in 2035. The net cost is estimated to range from 2.2 percent to 3.2 percent of export value.

Table 1. Key results from *A Storm in a Teacup*

	Net cost	Net cost as a % of China's EU CBAM exports	Net cost as a % of China's total EU exports
CBAM in 2026 (first year of implementation)	€146 million	2.2%	0.04%
CBAM in 2035 (fully implemented)	€208 million	3.2%	0.06%

Net costs are less than direct costs due to the countervailing effects of higher price and revenue, as shown in Figure 4, which graphs both types of costs for China and five other major EU trade partners. The graphs on the left show direct costs, i.e., border adjustment costs in isolation before accounting for resulting EU consumer price increases, while the graphs on the right show net cost. The top graphs present the 2026 results, assuming a 10 percent reduction in free allocation for EU producers, while the bottom graphs show year 2035 results assuming full implementation, meaning complete withdrawal of free allocation.

Figure 3. CBAM fees and net costs for major exporters to the EU in 2026 (top) and 2035 (bottom)[10]



A Storm in a Teacup finds China's direct costs are more than twice as large as its net costs when the EU CBAM is fully implemented, as Figure 3 shows. In other words, accounting for carbon price pass-through lowers estimated costs by more than half.

Another topic *A Storm in a Teacup* sheds light on is scope of industry coverage under the EU CBAM. The study analyzes a hypothetical extension of the EU CBAM to the key downstream products eligible for coverage, such as steel pipes, containers, and railway materials. *A Storm in a Teacup* finds expanding the covered industries to include downstream products nearly doubles direct cost for Chinese enterprises, from €424 million to €827 million.[11]

CHINA POLICY RECOMMENDATIONS

Recommendations for China to manage the effects of the EU CBAM are twofold. First, on policy, China is urged to move forward with expanding and strengthening the CN ETS. Second, on political dynamics, China should spotlight the economic upsides of clean tech leadership and alignment with national economic strategy to build support for decarbonization policies. To drive home the opportunity, these recommendations are followed by a case study about the rising prospects of low-carbon hydrogen and investments and innovation by Chinese enterprises.

EXPAND AND STRENGTHEN THE CN ETS

Continued decarbonization will lessen Chinese exposure to potential costs created by the EU CBAM. It will be key for China to follow through on its planned climate policies and investments, as it has done in the past.[v] It should also move expeditiously to include additional sectors under the CN ETS, including aluminum and iron and steel, as a strategic response to the EU CBAM to reduce exposure to carbon border adjustment costs.

Chinese enterprises covered under a strengthened CN ETS will see reduced CBAM fees for two reasons: lowered emissions intensity, and a smaller difference between EU and Chinese carbon prices. In addition to the direct benefit of lower border adjustment costs, inclusion under a strengthened CN ETS would enhance Chinese competitiveness in an increasingly carbon-constrained world. Stronger policy will accelerate learning curve effects, thus boosting domestic innovation and making Chinese clean tech enterprises more competitive.

Tsinghua University Professor Duan Maosheng and co-authors identify expanded CN ETS coverage as a key strategic response: "If the EU CBAM is fairly designed and carbon costs in other countries are reasonably credited, expansion of China's national ETS to cover CBAM-related sectors could be one of China's best policy instruments for responding to the mechanism."[12]

RAISE AWARENESS OF CN ETS ALIGNMENT WITH CHINA'S ECONOMIC STRATEGY

Underappreciation of several points of alignment between China's national economic strategy and ETS expansion and strengthening (hereafter referred to as "strengthening") creates an opportunity. The MEE and other officials at the forefront of China's climate policy need to use this advantage more effectively. A major new communication effort to spread understanding of the economic upsides can help clear obstacles to ETS strengthening.

Alignment between China's national economic strategy and ETS strengthening occurs in several ways. Greater domestic technological innovation and advancement of Chinese firms up the global value chain are the most obvious economic advantages of CN ETS strengthening. There is also self-evident correspondence between CN ETS strengthening and China's goal of increasingly relying on markets for more efficient resource allocation. In addition, strengthening the CN ETS will advance the macroeconomic goal of pursuing high-quality development, which recognizes that narrow macroeconomic metrics, such as gross domestic product, fail to account for the importance of clean air and other essentials for a good standard of living.

Low-carbon, energy efficiency, and other industries important for carbon neutrality have been identified as strategic priorities for economic development for over a decade, such as in China's 12th Five-Year Plan for 2011-2015.[13] The CN ETS's emissions reduction requirements will spur enterprises to be creative and efficient, creating learning and yielding economies of scale. The interdisciplinary study of technology learning curves is leading to increasing predictability of enhancements to innovation and falling costs due to climate policy strengthening.[14,15,16,17]

CN ETS strengthening will deliver these innovation and competitiveness benefits at the same time global markets are increasingly demanding low-carbon products. Global investment in decarbonization technologies reached $755 billion in 2021, a 25 percent increase over the year before, and a continuation of steady growth considering the need to build up clean energy and infrastructure.[18] BlackRock, Inc., the

---

[v] Interested readers may wish to consult the first and second reports in this series for more specific recommendations on expanding and strengthening the CN ETS.

largest assessment manager in the world, and other large investment firms have made specific commitments to screen out carbon-intensive projects.[19]

Motor vehicles are an example of progress and commitments to decarbonization at the industry level. A near consensus has emerged that electric vehicles now offer a rapid, economically attractive path to low-carbon transportation. A less well-known story, but one remarkable for the degree of international consensus, hails from the humble world of refrigeration. The Kigali Agreement will phase out carbon-intensive refrigerants in a treaty signed by 197 countries and ratified in 2019.[20] Remarkable enthusiasm is also evident in the concrete sector. The Global Cement and Concrete Association's *Climate Ambition Statement* promises continuous improvement in carbon intensity on the path to zeroing out GHG emissions across the industry's entire value chain by 2050.[21]

The Boston Consulting Group has concluded all companies face a risk of "not being funded anymore if they don't develop a sustainability strategy."[22] The CN ETS will have competitiveness benefits for Chinese enterprises because every industry needs a roadmap for carbon neutrality.

Dai Yande, former deputy head of the Energy Research Institute under the National Development and Reform Commission, summarizes the alignment between decarbonization and China's economic strategic interests this way: "Today 20 percent of [China's] energy consumption is directly or indirectly associated with exports. While CBAM is controversial, it can push positive changes in China's export patterns, which currently rely on cheap resources and labor forces. China needs to transform and get rid of its position at the lower end of the global supply chain."[23]

CLEAN STEEL CASE STUDY

Advanced manufacturing is generally defined to include production of not only novel products, but also existing products made using innovative techniques. According to BloombergNEF's analysis, the future is one of continued robust demand for low-carbon versions of basic inputs, for example, low-carbon steel.[24]

China has already established ambitious goals for the steel sector, including carbon emissions peaking by 2025 and a 30 percent reduction in carbon emissions by 2030.[25] Additionally, China's largest steel enterprise, Baowu, has committed to reaching carbon neutrality by 2050.[26] The company is experimenting with the use of microwaves to replace coal in the sintering step in the steelmaking process and has also announced it will build a 1 million tonne hydrogen-fired furnace.[27] To fuel the furnace, Baowu plans to use green hydrogen—hydrogen produced with energy from zero-carbon technologies. As explored in the second report in this series, green hydrogen is already an area of investment and technology development for Chinese companies.[28]

The global steel industry follows developments in China's steel sector with intense interest because of both these aggressive decarbonization targets and the sheer size of the sector. China produces more than half the world's steel. Figure 4 (below) breaks down steel output by company and country (or region), illustrating that Baowu and China are the globe's largest steel-producing company and country, respectively.

Demand for steel is expected to remain strong in a carbon-neutral world because steel is a key input in clean energy technology manufacturing. BloombergNEF New Energy Finance estimates that the world will need about 1.7 billion tons of steel for wind turbine manufacturing alone over the next three decades—the amount needed to build the Golden Gate Bridge 22,224 times over.[29] Almost the same amount of steel demand is forecasted to manufacture solar panels and grid pylons (supporting electricity transmission lines). Taken together, solar panel and grid pylons are projected to require 17,997 Golden Gate Bridges worth of steel, as depicted in Figure 5 (below).[30]

Figure 4. Global steel production and decarbonization commitments[31]

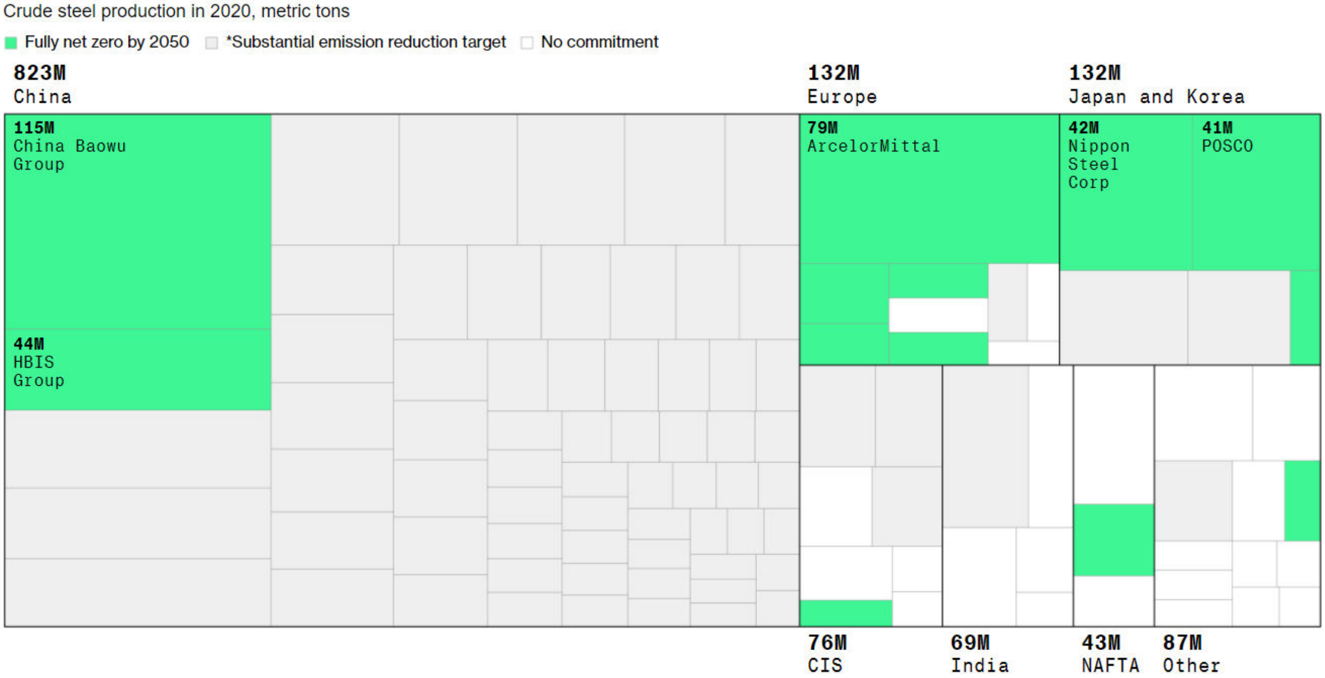
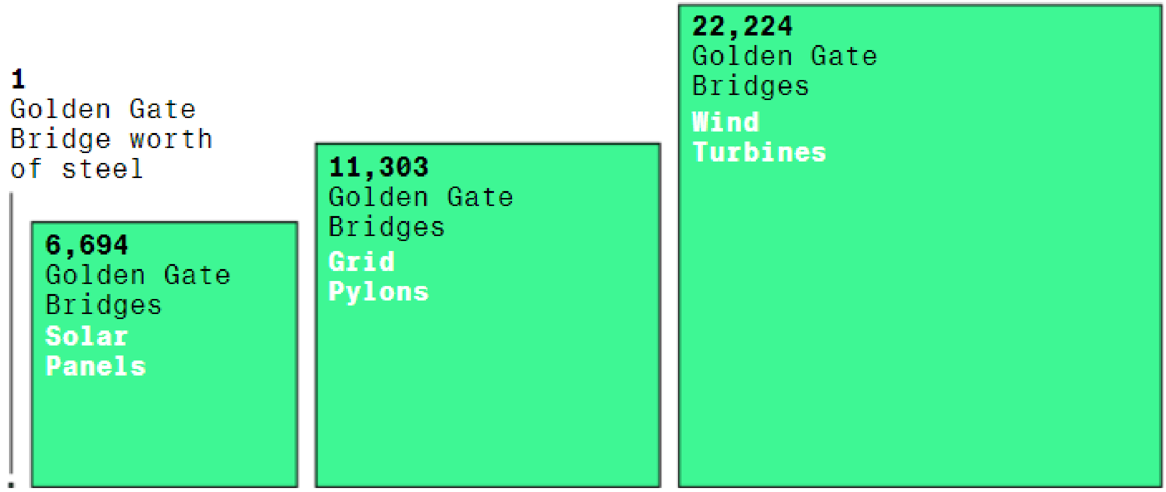


Figure 5. Decarbonization is expected to drive large demand for low-carbon steel[32]



EU POLICY RECOMMENDATIONS

The EU wants trade partners to follow its lead in reducing emissions, rather than to alienate them. If the EU improves ETS efficiency at a cost of losing the political narrative around global mitigation, that would not be a worthwhile tradeoff from the EU perspective.

To smooth acceptance and help trading partners to transition successfully, the EU should dedicate a portion of fees collected under the CBAM to technical assistance for developing countries. Doing so would address the concerns that the CBAM violates the principle of "common but differentiated responsibilities," which was first enunciated in 1991, in the document defining the United Nations Framework Convention on Climate Change.[33] Equity concerns remain front and center in international discussions. Although several major EU member states—namely, France, Germany, and Norway—are leaders in international climate assistance, that has not changed the intensity of opposition to the CBAM. Directly addressing equity concerns with revenue generated by the mechanism would likely lessen resistance to the CBAM by EU trading partners.

Funds should be used for either technical assistance or decarbonization investments. Technical assistance funding could support data monitoring, reporting, and verification systems, building governance capacity. In turn, these investments in monitoring, reporting, and verification will help lay a foundation for ratcheting up global controls on carbon emissions. Funding decarbonization projects, especially in the least industrialized countries, would directly advance adoption of lower-carbon technologies where income constraints are most severe. Both technical assistance and decarbonization investments would support key developments needed for the CBAM to work as intended.

Overall, the EU's initial proposal reflects an understandable balancing of emissions reduction objectives with technical and political economy challenges. Export rebates, appropriately, appear to be completely off the table. These rebates would undercut the carbon price signal for EU production destined for export, introduce legal uncertainty, and reduce international acceptance.

Future iterations of CBAM design should go beyond crediting policies that explicitly set carbon prices, such as carbon taxes or carbon markets. Even if a carbon price is not directly observable, it can be inferred from data on emissions reductions and costs. Such implicit prices are sometimes called "shadow" carbon prices.

Accounting for shadow carbon prices, at least for some subset of major policies, is advisable to head off a point of future friction. China's climate strategy, for example, includes a significant component of efficiency standards. Indeed, energy efficiency joins efficient carbon mitigation as one of the two foci of China's "dual control" strategy for energy sector development.[34]

CONCLUSION

The best quantitative evidence shows that the EU CBAM should have only small negative effects on China overall. Even in the most directly affected industries, negative effects are manageable. Increasingly, Chinese industry, investors, and policymakers are seeing economic opportunity in climate policies.

It would be a mistake to underestimate the challenges of achieving carbon peaking and carbon neutrality goals. Still, these challenges pale in comparison to those posed by doing too little to halt climate change. Recommendations developed here for China and the EU are designed to send cooperative signals and support a win-win outcome, with the intention of a contributing to a virtuous cycle of increasing trust and cooperation.

For China, strengthening the CN ETS, including hastening expanded sector coverage, will induce faster technological progress, improving the competitiveness of Chinese enterprises in a carbon-constrained world. At the same time, China would demonstrate its deepening commitment to decarbonization. This would signal to the EU that the CBAM is working as intended, demonstrating the effectiveness of a new approach to managing leakage and competitiveness concerns and supporting deeper decarbonization of key industries. At the same time, a stronger CN ETS would reduce the incentive for the EU to pursue a wholesale expansion, a welcome development for China.

EU recommendations will pay off through smoother implementation, more international acceptance of the CBAM, and improved legal standing. But the ultimate prize for the EU, which has worked hard to build cooperation with China on climate, would be the avoidance of a breakdown in relations and a deepening and productive partnership on climate. EU-China cooperation, not recrimination, will be essential to the success of global efforts to limit climate change.

APPENDIX A. GLOSSARY

Term	Definition
Border adjustment	A trade policy mechanism used to achieve the goal that consumers of a good or service pay the same tax regardless of whether the good or service is imported or produced locally. A border adjustment typically works by applying a tax to imports and offering a rebate on exports.
Competitiveness	The ability to compete successfully with other companies or countries.
Direct cost	Calculated as an unadjusted border adjustment fee, i.e., without consideration of expected follow-on dynamics, such as countervailing effects of higher price and revenue.
Emissions intensity	Emissions intensity, sometimes referred to as energy intensity or cost intensity, refers to the magnitude of carbon-price-related costs as a share of total production cost or value added in production.
Emissions-intensive, trade-exposed	Emissions-intensive, trade-exposed (EITI) industries qualify under emissions-intensity and/or trade-intensity thresholds for vulnerability to leakage. In the EU ETS's Phase Four (2021-2030), an industry qualifies as an EITE industry if the product of emissions intensity and trade intensity is greater than 0.2.[35]
Leakage	The potential for more stringent domestic regulation to cause shifts in production or investment to other jurisdictions with fewer constraints on emissions. Should it occur, leakage results in fewer emissions reductions than intended and leads domestic producers to lose market share to more emissions-intensive competitors.
Net cost	Includes both direct cost from the introduction of border fees and follow-on price and revenue effects.
Trade intensity	The exposure of domestic producers to foreign competitors. Trade intensity is measured by the share of imports and share of exports relative to revenue. The EU ETS calculates trade intensity by the formula (imports + exports) / (imports + production). The presence or absence of foreign competition acts as a proxy for domestic producers' ability to pass through carbon price costs to customers without losing profit or market share to international competitors.

APPENDIX B. MORE ABOUT RELEVANT RESEARCH

Appendix B covers results and methods of relevant research. Most analyses suffer from several divergences from reality in their representation of the EU CBAM and determinants of its effects. Among the reasons is the lack of certainty and evolving expectations for EU CBAM design. At the dawn of 2022, though choices remain to be formalized, time has rendered the outlines of the program much clearer.

Published in August 2021, *A Storm in a Teacup* offers the best insights into expected EU CBAM effects for China because its modeling is the most realistic, better lining up with the expected initial narrow scope of the policy for sector and emissions coverage. The carbon price in *A Storm in a Teacup* is a reasonable approximation at €60 per tonne, compared to around €75 per tonne at time of publication. No other study we uncovered better accounts for the unprecedented increases in EU carbon prices throughout 2021.[36] *A Storm in a Teacup* also has the advantage of accounting for increased revenue from expected higher prices in the EU for CBAM-covered products, yielding both direct and net-cost perspectives.

A Storm in a Teacup is somewhat pessimistic about business-as-usual innovation trends. It holds emissions intensity of production constant at 2020 levels, underrepresenting the pace of decarbonization underway in China. Improved emissions intensity of industry output will likely reduce Chinese enterprises' exposure to additional EU CBAM costs. Failure to account for such expected future innovation overstates the likely additional costs under the EU CBAM.

Comparing *A Storm in a Teacup* to Kuusi et al., another major study, is instructive. The focus in Kuusi et al. is on the Feasible 2 scenario. Kuusi et al.'s analysis goes further in failing to account for China's planned clean energy investments and policies, effectively freezing the global energy technology and emissions profile as it was in 2014.

Another root cause of differences between the two studies is Kuusi et al.'s overly broad scope of emissions and industries covered. On emissions, Kuusi et al.'s analysis assumes inclusion of indirect emissions in all scenarios, a significant departure from expected initial inclusion of only direct emissions.

The scope of industry coverage closest to expected CBAM design in Kuusi et al. is the Feasible 2 scenario. It lines up with the five sectors (or products) expected for initial CBAM coverage. Still, because of data limitations, Kuusi et al. must aggregate trade in all metals, not only aluminum, iron, and steel. As a result, scope of industry coverage in Kuusi et al. is overly broad even in the Feasible 2 scenario.

Table 2 summarizes and compares methods used in *A Storm in a Teacup* and Kuusi et al., including that the analysis in Kuusi et al. is based upon an EU carbon price of €25/tonne. To create maximum alignment with Kuusi et al., results are also derived based on the same €60/tonne EU carbon price assumed in *A Storm in a Teacup.* The methodology in Kuusi et. creates a direct, linear relationship between the magnitude of the carbon price and its effects. This mathematical relationship enables extrapolation of results based on any possible price.

Despite this effort to reduce variation in assumptions and increase commensurability, remaining differences in methods and assumptions detailed in Table 2 cause different results. Table 3 presents findings from both studies, including results for Kuusi et al. under two different EU carbon price assumptions, the €25/tonne assumption listed in the article itself and a €60/tonne assumption chosen to align with the EU carbon price assumption in *A Storm in a Teacup.*

Table 2. Methodology comparison

	Kuusi et al.	*A Storm in a Teacup*
Carbon price	€25/tonne	€60/tonne
Covered emissions	Direct & indirect emissions	Direct emissions
Covered sectors	Feasible 2 scenario is closest	Tailored to expectations
Technology	2014 tethered[vi]	2020 tethered[vii]
Trade data	2020	2019
Indirect price effects	Not considered	Yes, included
Resource shuffling	Not considered	Not considered

Table 3. Additional results and comparison of *A Storm in a Teacup* and Kuusi et al.

Scenario	Study	Cost	Cost as % of China's CBAM exports to EU	Cost as % of China's total EU exports
Net cost in 2026	*A Storm in a Teacup*	€146 million	2%	0.04%
Direct cost in 2026	*A Storm in a Teacup*	€174 million	3%	0.05%
Net cost in 2035	*A Storm in a Teacup*	€208 million	3%	0.06%
Direct cost in 2035	*A Storm in a Teacup*	€484 million	7%	0.14%
€25/tonne EU carbon price	Kuusi et al.	€905 million	8%	0.15%
€60/tonne EU carbon price	Kuusi et al.	€2,174 million	20%	0.36%

Turning to consideration of sector-by-sector impacts, *A Storm in a Teacup* provides insights comparing CBAM effects to existing EU tariffs. The paper develops metrics comparing, for each product, the cost of either policy. For both the CBAM and existing EU import tariffs, the percent increase is calculated relative to the product price before factoring in either tariffs or a potential CBAM fee.

Results shown in Table 4 indicate the EU CBAM will have smaller effects than existing tariffs for aluminum and steel, but could more than double existing tariffs for fertilizers, a significant new drag on fertilizer exports.

[vi] The caption under Table 5.2.2.1. notes that, apart from changes in trade patterns, "world input–output structure otherwise remains the same as in our [World Input-Output Database] data for the year 2014."

[vii] Page 35 notes the analysis assumes "2019 import volumes and emissions intensities."

Table 4. Percentage increase in product price: existing EU tariffs vs. CBAM effects[37]

Products	Existing EU import tariff[viii]	CBAM effect[ix]
Iron and steel	7%	2%
Aluminum	22%	6%
Fertilizers	6%	14%
Cement	2%	5%

One caveat about results in Table 4 are that they make static technology, energy, and emissions data assumptions, which is at odds with commitments to continue lowering emissions intensity. Compared to real-world expectations, these assumptions provide an unrealistic upward cost bias. China's continued efforts to lower emissions intensity will lessen the effects of the CBAM. Recent analysis by Credit Suisse underlines the importance of sustained policy and emissions reduction progress for the future competitiveness of CBAM-covered industries, concluding: "Without accelerated decarbonization, China's steel and aluminum exports to the European market could no longer hope to compete, while fertilizers also face major impacts."[38]

REFERENCES

[1] Eco Logic Sustainable Quality Consult, "Evaluation of the EU ETS Directive: Carried out within the Project 'Support for the Review of the EU Emissions Trading System'" (Vienna: European Commission, November 2015), https://www.ecologic.eu/sites/default/files/publication/2015/2614-04-review-of-eu-ets-evaluation.pdf.

[2] European Commission, "Proposal for a Regulation of the European Parlaiment and of the Council Establishing a Carbon Border Adjustment Mechanism" (Brussels, July 14, 2021), https://ec.europa.eu/info/sites/default/files/carbon_border_adjustment_mechanism_0.pdf.

[3] Andrei Marcu and Michael Mehling, "EU Carbon Border Adjustment Mechanism: Brief for Policy Makers" (Brussels: European Roundtable on Climate Change and Sustainable Transition, September 27, 2021), https://ercst.org/eu-cbam-brief-for-policy-makers/.

[4] European Commission, "Carbon Border Adjustment Mechanism: Questions and Answers," July 14, 2021, https://ec.europa.eu/commission/presscorner/api/files/document/print/en/qanda_21_3661/QANDA_21_3661_EN.pdf.

[5] Adrien Assous et al., "A Storm in a Teacup: Impacts and Geopolitical Risk of the European Carbon Border Adjustment Mechanism" (Sandbag & E3, August 2021), https://www.e3g.org/wp-content/uploads/E3G-Sandbag-CBAM-Paper-Eng.pdf.

[6] Assous et al., "A Storm in a Teacup."

[7] Christopher Kardish et al. (2021), *The EU carbon border adjustment mechanism (CBAM) and China: unpacking options on policy design, potential responses, and possible impacts*, Berlin: Adelphi,

[viii] Existing EU tariff rate calculated as the mean of tariff rates listed in *A Storm in a Teacup's* Table 7 (the default tariff rate, the minimum individual firm tariff rate, and the maximum individual firm tariff rate).

[ix] CBAM effect is calculated based on net cost, i.e., including indirect price effects.

https://www.adelphi.de/en/system/files/mediathek/bilder/20210610%20PolicyPaperCBAM%20China_Final.pdf.

[8] Elisabetta Cornago and Sam Lowe, "Avoiding the Pitfalls of an EU Carbon Border Adjustment Mechanism" (Centre for European Reform, July 5, 2022), https://www.cer.eu/sites/default/files/insight_CBAM_EC_SL_20.7.21.pdf.

[9] Andrei Marcu, Aaron Cosbey, and Michael Mehling, "Border Carbon Adjustments in the EU: Sectoral Deep Dive" (Centre for European Reform), accessed September 27, 2021, https://ercst.org/border-carbon-adjustments-in-the-eu-sectoral-deep-dive/.

[10] Assous et al., "A Storm in a Teacup."

[11] Assous et al., "A Storm in a Teacup."

[12] Kardish et al., *The EU Carbon Border Adjustment Mechanism and China.*

[13] Tristan Kenderdine, "China's Industrial Policy, Strategic Emerging Industries and Space Law," *Asia & the Pacific Policy Studies* 4, no. 2 (2017): 325–42, https://doi.org/10.1002/app5.177.

[14] François Lafond et al., "How Well Do Experience Curves Predict Technological Progress? A Method for Making Distributional Forecasts," *Technological Forecasting and Social Change* 128 (March 1, 2018): 104–17, https://doi.org/10.1016/j.techfore.2017.11.001.

[15] Rupert Way et al., "Empirically Grounded Technology Forecasts and the Energy Transition" (Institute for New Economic Thinking, Oxford University, September 14, 2021), https://www.inet.ox.ac.uk/files/energy_transition_paper-INET-working-paper.pdf.

[16] Kelly Sims Gallagher, "Why & How Governments Support Renewable Energy," *Daedalus, MIT Press Journals* 142, no. 1 (January 2, 2013): 59–77, https://doi.org/10.1162/DAED_a_00185.

[17] Kelly Sims Gallagher and Fang Zhang, "Innovation and Technology Transfer Across Global Value Chains: Evidence from China's PV Industry" (Tufts University, July 2013).

[18] Nathaniel Bullard, "Where the Billions Pouring into the Energy Transition Are Going," *Bloomberg LP*, January 27, 2022, https://www.bloomberg.com/news/articles/2022-01-27/where-the-billions-pouring-into-the-energy-transition-are-going.

[19] Kimberly Chin, "Corporate Venture Investors Boost Climate-Tech Spending," *Wall Street Journal*, March 16, 2022, sec. WSJ Pro, https://www.wsj.com/articles/corporate-venture-investors-boost-climate-tech-spending-11647432001.

[20] Jeff Mason, "White House Sends Kigali Amendment on Climate-Warming Gases to Senate," *Reuters*, November 17, 2021, sec. COP26, https://www.reuters.com/business/cop/white-house-send-kigali-amendment-climate-warming-gases-senate-officials-2021-11-16/.

[21] Global Cement and Concrete Association, "GCCA Climate Ambition Statement: Toward Carbon Neutral Concrete," 2020, https://gccassociation.org/wpcontent/uploads/2020/09/GCCA_ClimateAmbitionStatement_Print_AW.pdf.

[22] Chin, "Corporate Venture Investors Boost Climate-Tech Spending."

[23] Ivy Yin, "China Wary of Socio-Economic Impact of Unregulated Carbon Market," *S&P Global Platts*, July 7, 2021, https://www.spglobal.com/platts/en/market-insights/blogs/energy-transition/070721-china-carbon-market-emissions-socio-economic-impact-power-industry.

[24] Eddie Spence, Sam Dodge, and Akshat Rathi, "The Green Revolution Is Being Built on a Very Dirty Industry," *Bloomberg*, June 13, 2021, https://www.bloomberg.com/graphics/2021-green-steel/.

[25] Spence, Dodge, and Rathi, "The Green Revolution."

[26] Spence, Dodge, and Rathi, "The Green Revolution."

[27] Bloomberg News, "The Chinese Companies Polluting the World More Than Entire Nations," *Bloomberg.com*, October 24, 2021, https://www.bloomberg.com/graphics/2021-china-climate-change-biggest-carbon-polluters/.

[28] Peter Kiernan, "China's Sinopec Starts Construction of 300 MW Green Hydrogen Project," *Carbon Pulse*, November 30, 2021, https://carbon-pulse.com/145416/.

[29] Spence, Dodge, and Rathi, "The Green Revolution."

[30] Spence, Dodge, and Rathi, "The Green Revolution."

[31] Spence, Dodge, and Rathi, "The Green Revolution."

[32] Spence, Dodge, and Rathi, "The Green Revolution."

[33] United Nations Framework Conventional on Climate Change, "Report of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change on the Work of the Second Part of Its Fifth Session," May 9, 1992, https://unfccc.int/documents/951.

[34] Carbon Brief, "China Briefing: Widespread Power Cuts; New Orders on 'Dual Control'; Emissions Peak Likely 'before 2028,'" *Carbon Brief* (blog), September 30, 2021, https://www.carbonbrief.org/china-briefing-30-september-2021-widespread-power-cuts-new-orders-on-dual-control-emissions-peak-likely-before-2028.

[35] European Commission, "Adoption of the Delegated Decision on the Carbon Leakage List for 2021-2030."

[36] International Carbon Action Partnership, "Allowance Price Explorer," International Carbon Action Partnership, accessed October 29, 2021, https://icapcarbonaction.com.

[37] Assous et al., "A Storm in a Teacup."

[38] Stian Reklev, "CBAM to Leave Chinese Steel, Aluminum Uncompetitive in Europe without Fast Emissions Cuts, Credit Suisse Warns," *Carbon Pulse*, September 29, 2021, https://carbon-pulse.com/139917/.