Overcoming Obstacles to Expanded Industry Coverage Under China's National Carbon Emissions Trading System

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APRIL 2022

SUMMARY

Expanded industry coverage is a key next step for China's national carbon emissions trading system (CN ETS).[i] This expansion will almost double emissions covered under the CN ETS compared to its initial scope, which focused on electric power generation. Six sectors have been identified for addition to the CN ETS: the combined category of iron and steel, aluminum, cement, chemicals, papermaking, and civil aviation.[1]

CN ETS expansion to include additional industries may occur soon, but this step has been delayed. China could extend CN ETS coverage to production of aluminum and cement as early as 2022.[2] Currently, however, there is no official timetable for when new industries will be added.

Sectors to be added under the CN ETS include industries with greater exposure to international trade than the electric power producers initially covered. Information challenges make it challenging for policymakers to completely rebut competitiveness concerns, despite several factors moderating concerns about international competitiveness impacts.[3]

[i] This report uses the more common term "emissions trading system," while noting that officials typically refer to China's program as the national carbon market.

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Two policy recommendations are offered to manage information constraints and economic fears: setting a price collar and minimizing the number of allocation benchmarks.

Setting a price collar identifies maximum and minimum acceptable carbon allowance prices, thereby strictly ruling out carbon price spikes. Thus, a price collar directly limits economic risk and lessens economic concerns. A price collar delivers communications benefits by offering a straightforward, readily explainable approach to cost containment. A price collar also eases information hurdles by giving policymakers the confidence to move forward with a less exhaustive characterization of each industry's technological and market situation.

Benchmark simplification can help overcome information gaps because setting multiple technology-based benchmarks requires a detailed knowledge base. Therefore, the Ministry of Ecology and Environment (MEE) should minimize the number of benchmarks, aiming for one benchmark per unique product. A single benchmark per product obviates the need to develop a comprehensive inventory of technology, fuel use, emissions, and production methods in each industry the MEE adds.

Spotlighting the economic benefits for industries due to inclusion in the CN ETS and how these benefits align with China's national economic strategy will counter competitiveness concerns, building support for expanded CN ETS coverage. Industries added to the CN ETS will see faster innovation and improved clean tech competitiveness at a time of burgeoning international demand for low-carbon products. Investment in decarbonization technologies surged by 25 percent globally in 2021 and doubled over the last five years.[4] Accelerating domestic innovation and bolstering the competitiveness of Chinese enterprises engaged in advanced technology manufacturing have been long-standing development priorities for China.

This report develops a three-step approach for overcoming informational difficulties and political economy obstacles to expanding industry coverage under the CN ETS. First, address competitiveness concerns by introducing a price collar. Second, embrace benchmark simplification and reduce allocation benchmarks to the minimum viable number, aiming for one per each unique product. Third, spotlight the growing clean tech opportunities that will be enhanced for industries added to the CN ETS and build understanding of how these outcomes align with national economic strategy. Taking these three steps will help smooth the path for expanding industry coverage under the CN ETS, an essential measure if the program is to become an important driver of emissions reductions as envisaged by China's decarbonization strategy.

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INTRODUCTION

This report explores the topic of expanding the CN ETS to cover additional industries. In its first phase, the CN ETS exclusively regulates electricity generation. Broader coverage has long been intended, but the schedule for adding industries is uncertain.

To shed light on the delay, this report begins with an explanation of leakage and competitiveness concerns that are more salient for sectors to be added to the CN ETS than for electric power generation. After an update on program implementation (in “Status of ETS Expansion”), the specific challenges policymakers at the MEE have encountered are examined (in “Obstacles to ETS Expansion”). Next, recommendations are developed, starting with two policy design strategies for surmounting technical and political economy hurdles. The report concludes by urging policymakers to spotlight economic upsides for industries that will be brought under the CN ETS and to raise awareness of how these benefits align with China’s national economic strategy. A “Green Hydrogen Case Study” explores a low-carbon fuel positioned for strong global growth, explains how CN ETS expansion would advance prospects for Chinese enterprises developing a green hydrogen supply chain, documents actions Chinese enterprises have taken to position themselves for green hydrogen success, and outlines prospects for future growth in global demand.

This report is the second installment in a three-report series. The first report offers overarching recommendations to improve the efficiency of the CN ETS, while also enhancing the program's climate effectiveness. The third report evaluates the European Union's proposed carbon border adjustment mechanism and its implications for China.

LEAKAGE AND COMPETITIVENESS EFFECTS

Unlike the initially covered power sector, sectors to be added have non-trivial export components, and some other ETS programs consider them to be at risk of leakage. While leakage and competitiveness are unavoidable topics for CN ETS expansion, industry tends to exaggerate these concerns in resisting tougher policies. After some definitional work, this section explains several factors serving to constrain leakage impacts for Chinese enterprises. The section wraps up with a survey of key quantitative analysis of leakage and competitiveness effects expected for Chinese industries subject to future CN ETS coverage.

DEFINING LEAKAGE AND EMISSIONS-INTENSIVE, TRADE-EXPOSED INDUSTRIES

In climate policy, "leakage" refers to the potential for new regulation such as carbon pricing to cause shifts in economic activity and associated emissions to jurisdictions with more permissive emissions controls. Evaluating and accounting for leakage risk preserves environmental integrity and builds political support. Leakage is a function of two factors: the quantity of production shifted beyond the reach of the new regulation and the difference in emissions intensity of consumer products due to import substitution. Leakage can be represented mathematically as follows:[5]

Leakage = change in production x change in CO_2 *emissions intensity*

To define the terms in the equation above, ***"change in production"*** refers to the quantity of production shifted from domestic to foreign manufacturers. This could be measured, for example, as tonnes of steel. "***Change in*** CO_2 ***emissions intensity"*** refers to the average difference in emissions intensity between production of additional imports and the domestic production it is replacing. This could be measured, for example, as tonnes of carbon dioxide (CO_2) emitted per tonne of steel produced.

ETS design commonly identifies certain producers and sectors at risk of leakage, referred to as emissions-intensive, trade-exposed (EITE) industries. The specifics of EITE industry classification vary from program to program but typically reflect two considerations. First, emissions-intensive industries face potentially large production cost impacts from the introduction of carbon pricing due to reliance on fossil fuel combustion. Second, trade-exposed enterprises face competition from large shares of imports in their domestic markets or export a large share of their production.

The approach to classifying industries as EITE industries in the EU ETS provides an instructive example. Emissions intensity is calculated as the added costs due to carbon pricing per unit of output over total domestic value creation.[ii] Trade intensity depends on the prevalence of imports and exports compared to

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[ii] In the EU ETS, this metric is referred to as cost intensity and is calculated as follows: cost intensity = [carbon price × (direct emissions × auctioning factor + electricity use × emission factor)] / gross value added.

the market share of EU companies.[iii] In Phase Four of the EU ETS, an industry qualifies for classification as an EITE industry if the product of emissions intensity and trade intensity is greater than 0.2.[6]

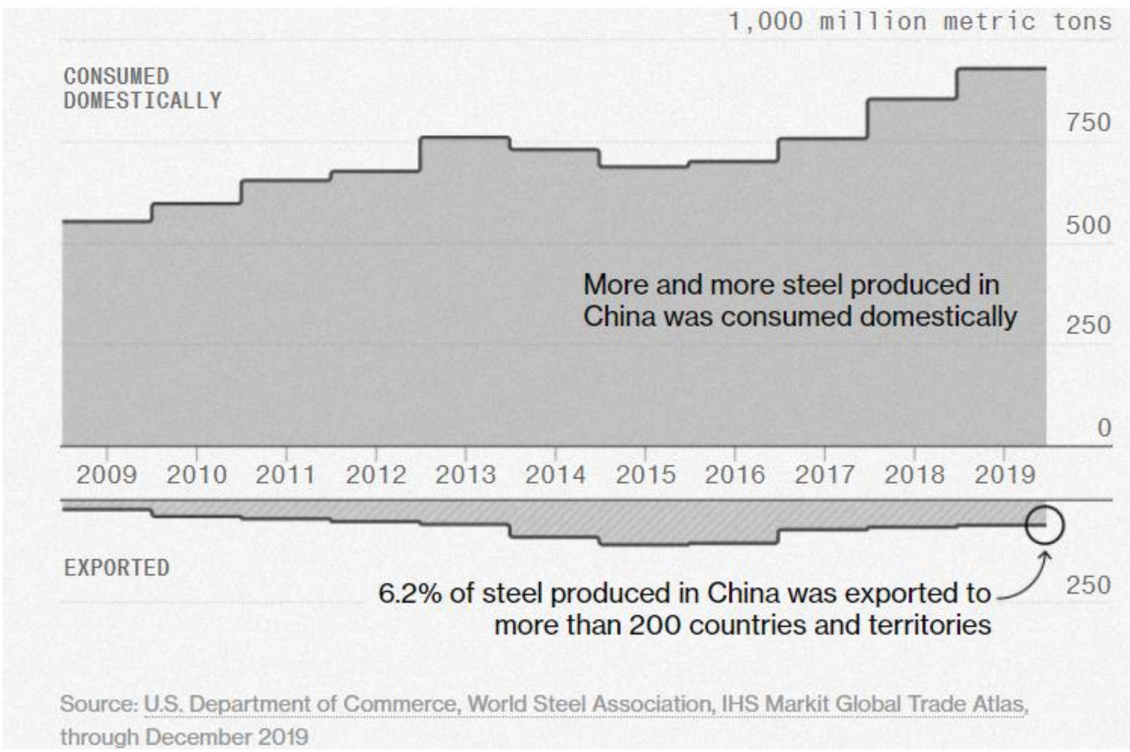
Historically, ETS design has used free allowance distribution—rewarding free allowances to EITE industries—as the main instrument for managing competitiveness and leakage concerns. The EU is now piloting a different approach of using carbon border adjustment fees, as discussed in the third report in this series.

FORCES MODERATING LEAKAGE RISK

Even for industries considered most at risk for leakage, several factors moderate leakage and competitiveness impacts. First, China's large domestic market, dominated by domestic producers, provides a buffer of sorts against competitiveness concerns.

Consider steel, for which China's domestic market has been of rising importance. Figure 1 shows that domestic consumers accounted for 93.8 percent of demand for China's steel in 2019.[iv]

Figure 1. The domestic market dominates demand for Chinese steel[7]



The outsized scale of Chinese production compared to that of other nations also moderates leakage risk, helping set expectations about technological trends. According to McKinsey & Company, "The industry is looking with a lot of interest at what is happening in China, just because of the sheer size of the Chinese industry."[8]

[iii] In the EU ETS, trade intensity is calculated as follows: trade intensity = (imports + exports) / (imports + production).

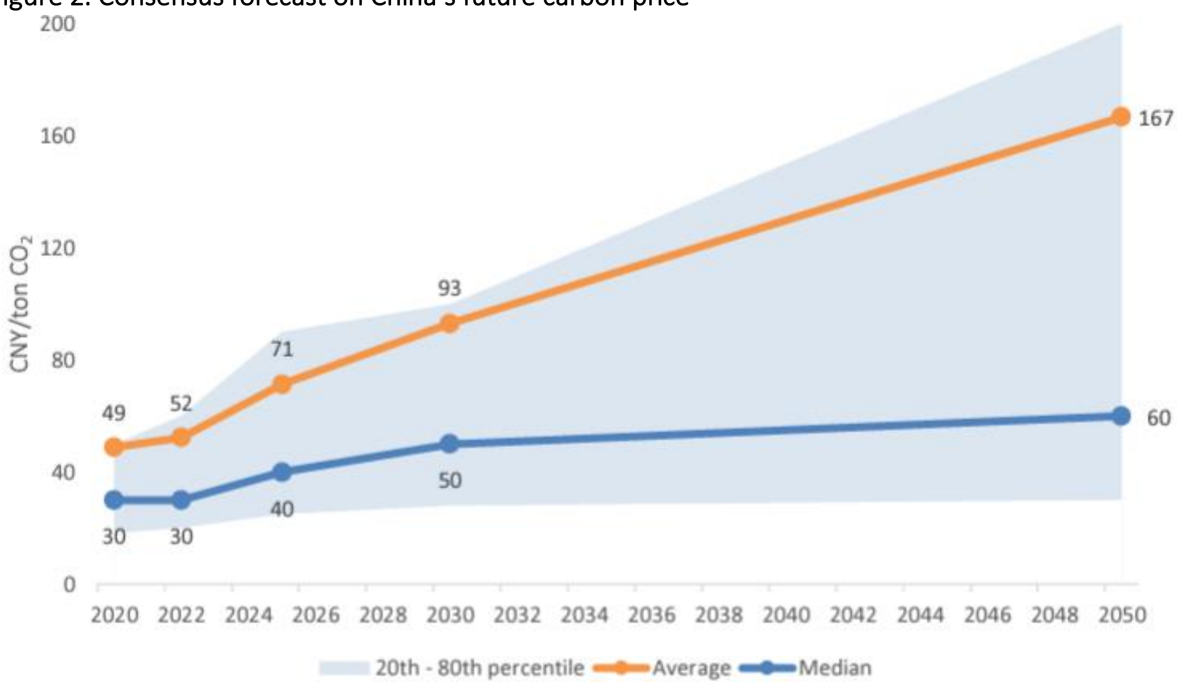
[iv] This conclusion is implied by the figure's annotation stating that exports accounted for 6.2 percent of China's steel production.

Another force moderating leakage and competitiveness effects is the growing economic upside for industries covered by the CN ETS. ETS coverage will directly lower border costs for Chinese enterprises under the EU's proposed carbon border adjustment mechanism. The economic benefits of CN ETS coverage in an increasingly carbon-constrained world are discussed below in the section called "Spotlight Economic Advantages."

QUANTITATIVE INSIGHTS INTO CN ETS EXPANSION IMPACTS

To evaluate studies of quantitative leakage and competitiveness impacts, it is important to consider those studies' assumptions. A key question to ask is how a study treats future carbon prices, given their significant role in determining ETS impacts. In 2021, China's carbon price ranged from ¥40 to ¥60 on the national trading platform after the July launch. Figure 2 shows a China carbon price forecast, i.e., a "consensus forecast" based on a survey of market participants. The orange line, representing average price, is skewed upward by a small number of outlier data points. The blue line graphs the median, i.e., middle-ranked, value. The median value is unaffected outliers, which explains the divergence between the average and median measures.

Figure 2. Consensus forecast on China's future carbon price[9]



The research literature suggests coverage under the CN ETS will result in manageable effects, even though studies typically assume higher future costs than does the consensus forecast. "Carbon Leakage Scrutiny in ETS and Non-ETS Industrial Sectors in China," by a team of Tsinghua University scholars, models a carbon price of ¥200 per tonne.[10] Even at this price, which the consensus forecast suggests is unlikely to be reached for decades, the research finds that modest levels of free allocation neutralize leakage. The research concludes, "The appropriate proportion of free allowances required for compensation varies between 15.8 percent and 17.0 percent" in a scenario with industry responsible for direct emissions on-site and with electricity prices shielded from carbon price effects.[11] If power sector reform allows cost pass-through to consumers, a larger share of allowances is needed to counteract leakage. Forty percent free allocation fully counteracts leakage in a power sector reform scenario allowing carbon price pass-through to electricity prices charged to large industry.[v] [12]

Research into leakage usually analyzes effects across international borders, but a different team from Tsinghua University investigated how subnational pilot ETS programs trigger leakage across provincial borders within China, finding evidence that both economic activity and emissions shift to areas outside of pilots.[13] This research confirms that leakage occurs more readily within national territories than across international borders. Importantly, national coverage as planned under the CN ETS would counteract the potential for such inter-provincial leakage within China.[vi,14]

STATUS OF CN ETS EXPANSION

The CN ETS has initially exclusively regulated CO_2 emissions from power plants, including units feeding the electrical grid and dedicated industrial facilities, covering about 2,200 enterprises.[15] In 2019, these enterprises began mandatory data reporting. In 2021, the CN ETS first began requiring covered enterprises to transfer carbon allowances, or tradable permits, to the government to account for a portion of their emissions.

China has long planned to include a broader array of industries in the CN ETS. When the intention to develop a nationwide ETS was first announced in 2015, it included plans for the program to cover "a substantial percentage of China's carbon pollution."[16] In 2016, the National Development and Reform Commission's Climate Office proposed coverage of emissions from electric power generation and six additional industries: the combined category of iron and steel, aluminum, cement, chemicals, papermaking, and civil aviation.[17]

In 2021, the MEE introduced mandatory data reporting requirements for these six sectors.[18] Such mandatory data reporting rules build up technical capacity within enterprises but are purely informational. The CN ETS will create a carbon price signal and start incentivizing emissions reductions only after it introduces obligations for enterprises to account for their emissions through deposit of carbon allowances.

The expansion of the CN ETS beyond electric power to these additional six sectors is expected during the 14th Five-Year Plan, i.e., no later than 2025.[19] Media reports quote the chair of the Shanghai environment exchange as saying the CN ETS will expand to regulate cement and aluminum starting in 2022.[20] Still, there is no official timetable for when the next industries will be added, much less when industry expansion will be completed.

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[v] "Carbon Leakage Scrutiny" further states: "The risks that carbon leakage will occur … are insignificant if the average auctioning factor of ETS is lower than 60 percent."

[vi] The research also touches on economy-wide policy design, concluding that a package of policies best achieves optimally effective, efficient, and equitable strategy: "In contrast with market-based mitigation regimes … a target-based policy like China's mandatory mitigation of the Five-Year-Plan shows its importance in achieving a more 'equal' carbon peak. However, it has little incentive for the subnational economies to make extra efforts once the mitigation target was realized. Therefore, for emerging economies like China, a hybrid mitigation policy would be necessary, especially considering that 'common but differentiated responsibility' is also important inside these economies."

OBSTACLES TO CN ETS EXPANSION

Information challenges, economic concerns, and bureaucratic inertia are key factors slowing expansion of CN ETS coverage to additional industries.[21] Beginning with information hurdles, these include the challenges related to both collecting and interpreting data. It is difficult to collect reliable emissions data, but at least this type of data is already a core competency for the MEE. Economic data are also required to address leakage and competitiveness effects. Adding multiple sectors at once also increases the complexity of the information landscape, involving much greater heterogeneity in fuels, technologies, and production processes than the MEE confronted initially.

Information challenges include not just data constraints but the lack of readily available analytical tools for extracting insights relevant to policy design from data. China gained experience with ETS design through eight pilot programs implemented at a subnational level. International institutions like the Partnership for Market Readiness and the International Climate Action Partnership are beginning to distill best practices in regulatory analysis for ETS design. Even if international best practices for regulatory analysis existed, the uniqueness of the Chinese context would still require the MEE to develop its own quantitative tools to inform CN ETS design.

The foregoing information challenges directly connect to obstacle number two, economic concerns. The lack of a stronger knowledge base makes it challenging for the MEE to resoundingly rebut worries about the potential for negative economic impacts. In China and countries the world over, industries facing ETS programs voice resistance and sometimes make unsupported claims that facing a carbon price would cause stark competitive disadvantages. ETS designers find it difficult to disprove even exaggerated fears when arguing with industry lobbyists armed with intimate knowledge of their customers, supply chains, and factories. In China, ETS expansion has been slowed by worries that aggressive implementation could cause widespread industry noncompliance, according to the carbon market consultancy Sino Carbon.[22][23]

A third challenge, bureaucratic inertia, arises from the lack of stronger legislative authority or State Council endorsement. For example, the CN ETS's economic implications require consultation with the National Development and Reform Commission, which is responsible for investment and macroeconomic planning. Another hurdle to expanded industry coverage is the need to overcome economic doubts and increase support for adding industries to the CN ETS in other government power centers.

POLICY RECOMMENDATIONS

Two policy recommendations can help to manage challenges stemming from information gaps and economic concerns. Setting a price collar will contain economic risk, reducing the potency of competitiveness concerns. Simplifying allocation benchmarks will help overcome information challenges.

SET A PRICE COLLAR

A price collar setting a ceiling and floor price for carbon allowances is the most efficient way to ensure carbon price stability, ruling out unacceptable volatility, which carries economic and political risks. The price ceiling element of a price collar sets an upper limit on compliance cost—the maximum allowable price per tonne. If a price ceiling is in place, the cost to emit one metric ton of CO_2 will stay at or below a known level regardless of the benchmark allocation. By ruling out worst-case scenarios, a price collar will help the MEE build support for CN ETS expansion in industry and in other government agencies.

A price collar also helps to surmount information obstacles. A price collar should provide greater confidence to the MEE or any ETS designer to move forward with a less exhaustive characterization of each industry's technological and market situation.

MINIMIZE ALLOCATION BENCHMARKS, AIMING FOR ONE PER UNIQUE PRODUCT

Initially, the CN ETS has taken the form of what is known as an output-based performance standard,[24] with no fixed emissions limit. Instead, such an approach achieves a given standard CO_2 intensity per unit of output. An allocation benchmark sets the quantity of free allowances that firms receive per unit of output.

To lessen information obstacles, CN ETS design should strive for simplification by minimizing the number of benchmarks for each industry, aiming for one benchmark per industry product. Avoiding technology-specific benchmarks reduces the information burden, lessening the importance of developing an intricate inventory of each industry's technology and fuel use.

Minimizing the number of benchmarks for each product also results in a clearer carbon price signal. Work by a team of Chinese and international scholars based at Stanford University shows how using multiple benchmarks sacrifices cost effectiveness: "Multiple benchmarks add to costs by affecting the relative strength of the subsidy across different covered facilities, distorting the relative contributions of different facilities to emissions abatement."[25] We recommend achieving equity goals through investment and other policies rather than through technology-differentiated benchmarks.

The first phase of the CN ETS uses four different technology benchmarks for electric power. The advantages of simpler benchmarks led to a paring down to four from an initial proposal for 11 different technology-specific benchmarks in the power sector. The highly uniform product of electrical energy is a ripe target for further reform to a single benchmark. The approach of using technology-differentiated benchmarks for power was driven by an equity objective, specifically cushioning those places where fluidizing coal plants, which burn low-quality coal resources and have high emissions, have historically been clustered.[26] However, efficiency would be advanced by adopting a single power sector benchmark and achieving fairness goals through other budgetary outlays.[27]

FURTHER CONSIDERATIONS

The recommendations from the first report in this series will also generally apply to newly covered industries. For example, in its initial phase, the CN ETS should transition from what is known as an output-based performance standard.[28] With this approach, the number of carbon allowances the program makes available adjusts according to actual production levels. As soon as possible, the CN ETS should transition to a fixed emissions limit, also known as a mass-based approach, in which the number of carbon allowances is set at a specific quantitative level. Under the recommended program design, this fixed emissions limit remains in force if the carbon price remains within a desired range, i.e., below the price collar's maximum level.

Transitioning to a fixed emissions limit approach will result in a policy instrument better suited to achieving China's goals of carbon peaking and carbon neutrality, which are commitments related to total emissions, not carbon intensity. China's international climate pledges and domestic policy reflect these commitments to carbon peaking before 2030 and carbon neutrality by 2060. For examples, China's dual control policy to guide its energy sector transition identifies two overarching imperatives, reducing total emissions as well as lowering emissions intensity of economic output. China's State Council recently issued an "Action Plan for Carbon Peaking Before 2030," providing further evidence of the growing importance of controlling total emissions.[29]

Regarding allowance allocation, the critical move to make is to introduce auctioning and, overtime, decrease the share of allowances distributed for free. Even a small amount of auctioning—2 percent to 5 percent of allowances—will deliver meaningful benefits, including a higher-quality price signal, lower transaction costs for trading, and more liquidity.[30] Consignment auctioning can help overcome hurdles to auctioning.[31,32]

To assist with future program design, we recommend investments to improve evaluation of impacts of alternative allocation approaches. Policymakers need better analytical methods to gauge leakage risk and the optimal level of support for industry. New optimization techniques would help align ETS policy with China's recent emphasis on common prosperity in economic development, a response to growing income inequality and private sector excesses.

Existing research indicates less than 100 percent of the allowance value might be needed to counter leakage risks for Chinese enterprises. In the previously discussed study "Carbon Leakage Scrutiny," modeling a carbon price of ¥200 per tonne and assuming coverage of indirect emission sources (i.e., grid-supplied electricity, with industry absorbing the carbon cost), the maximum level of free allocation required to neutralize leakage was 33.7 percent for the aluminum sector (referring to Table 3).[33]

The EU's experience offers a cautionary note about unintended overly generous industry allocation. Windfall profits for industry in the early years of the EU ETS damaged the program's public favorability.[34] Advances in methods for optimizing allocation and evaluating leakage risk will improve confidence in the fairness of CN ETS allocation methods and enhance alignment with the central government's common prosperity initiatives.

SPOTLIGHT ECONOMIC ADVANTAGES

A third recommendation is building support for CN ETS expansion by increasing understanding of associated economic benefits. The CN ETS will spur innovation in newly added industries, boosting prospects for Chinese enterprises competing in the clean tech space. Domestic innovation and improved international competitiveness upsides are even more compelling considering the alignment between these outcomes and China's national economic strategy.

The discussion that follows surveys parts of the cause-effect loop, starting with CN ETS coverage. The emissions reduction requirements introduced for industries added to the CN ETS spur faster domestic innovation through "learning curve" effects. As the scale of domestic production expands, economies of scale lower cost further, a competitiveness advantage economists call the "home market" effect. Together, these learning curve and home market dynamics will boost prospects for Chinese enterprises in burgeoning global clean tech markets—all outcomes aligned with China's national economic strategy.

"Learning curves" refers to the pattern of steadily improving performance and declining costs commonly observed for emerging technologies.[35] Most innovation does not occur through large breakthroughs, but by small improvements over time, sometimes due to discoveries in research settings and learning by doing through growing experience with manufacturing and use. In the last 20 years, studies using different methods—statistical analyses,[36] economic history,[37] and case studies[38]—have solidified the science of learning curves, finding "strong evidence that environmental regulations induce innovation activity in cleaner technologies."[39] Several studies have documented the learning curve effects in China's experience with clean energy.[40,41]

Growing production and use at home can also generate export benefits through the home market effect, which, backed by over a half century of evidence, demonstrates the export advantages that can follow early leadership in domestic use and economies of scale in production.[42,43,44] When early adopters gain a cost advantage from domestic experience, begetting future export success, that's the home market effect.

Due to learning curve and home market effects, CN ETS expansion will deliver innovation and economy-of-scale benefits at a time when international demand for clean tech products has matured, becoming mainstream. Decarbonization technologies surged by 25 percent globally in 2021, reaching $755 billion, doubling in value over the last five years.[45] Demand for lower-carbon products is growing in the specific industries to be added to the CN ETS. For example, demand for low-carbon steel for wind turbines alone is estimated to be 1.7 billion tonnes through 2050.[46]

The clean tech opportunity is compelling as a stand-alone narrative, but alignment with China's national economic strategy further amplifies its power. China has made clean energy supply and demand-side clean tech a strategic economic priority for at least a decade. For example, the 12th Five-Year Plan, running from 2011 to 2015, identified new energy sources, new energy vehicles, and energy-conserving technologies among priority economic development targets for boosting domestic technological progress and helping Chinese enterprises move up the value chain in international markets. Carbon-price-induced innovation provides a straightforward advantage, considering China's goals in strategic climate tech.

CN ETS expansion will also encourage quality economic growth over maximizing the rate of increase in gross domestic product. Since at least 2015, China's economic strategy has prioritized higher-quality development, recognizing environmental degradation as damaging to quality of life and economic performance.[47] CN ETS expansion corrects the failure of markets to account for air pollution, encouraging higher-quality growth.

Officials at the highest level recognize the economic opportunities in climate policy leadership.[48] For example, Xie Zhenhua, formerly China's Special Representative on Climate Change Affairs, said: "Policy actions to address climate change will not only not hinder economic development, but also help improve the quality of economic growth and foster new industries and markets."[49] Yet economic concerns in industry and among officials below top leaders continue to be an obstacle to CN ETS expansion, making these groups leading targets for an initiative to build awareness of the program's economic benefits.

GREEN HYDROGEN CASE STUDY

The CN ETS's carbon price signal will provide an advantage to lower-carbon hydrogen and prompt the accumulation of experience, generating innovation through learning curve effects. The acceleration of domestic innovation resulting from industry coverage under the CN ETS will enhance the competitiveness of Chinese firms in international hydrogen markets, which are likely to see strong growth in future years and decades.

Green hydrogen is expected to be a growing source of energy for low-carbon production globally, including in industries likely to be added to the CN ETS, for which low-carbon hydrogen probably will be the best low-carbon option as a heat source and for some chemical feedstocks.[50] The extreme heat demands of production make hydrogen combustion the highly likely low-carbon alternative, "unavoidable" in BloombergNEF founder Michael Liebreich's assessment.[51]

Hydrogen is a flammable gas, emitting no CO_2 when it burns. This makes hydrogen different from fossil fuels like natural gas and petroleum, whose combustion accounts for the vast majority of GHG emissions today. The carbon intensity of hydrogen depends on how the hydrogen is made.

Whereas most hydrogen is produced using fossil fuels, green hydrogen is produced with zero-emission electricity.[52] Learning curves are expected to bring down costs of the electrolyzers needed to make green hydrogen. More efficient use of electricity generating capacity is another promising avenue to lower green hydrogen costs. At times of low system demand, when insufficient storage capacity exists to soak up excess generation, zero-emission electricity is at risk of being wasted.[53] Making hydrogen from this otherwise unused, i.e., curtailed,[vii] electricity is a promising avenue being pursued to lower the cost of green hydrogen production.

Chinese enterprises are investing in both research and demonstrations, with plans to move to commercial-scale production. Longi Green Energy Technology Co. and other Chinese solar companies are investing in manufacturing of electrolyzers, the equipment needed to produce hydrogen with zero-emission electricity.[54]

Chinese companies are also taking steps to reach commercial-scale production. State-owned oil company Sinopec has committed to invest $4.6 billion in green hydrogen by 2025.[55] In 2021, the company announced it had begun construction of the largest solar-powered hydrogen production facility anywhere, powered by a 300-megawatt solar plant built to provide a dedicated source of low-carbon energy. Sinopec plans for this solar-powered hydrogen plant to begin production in 2023.[56]

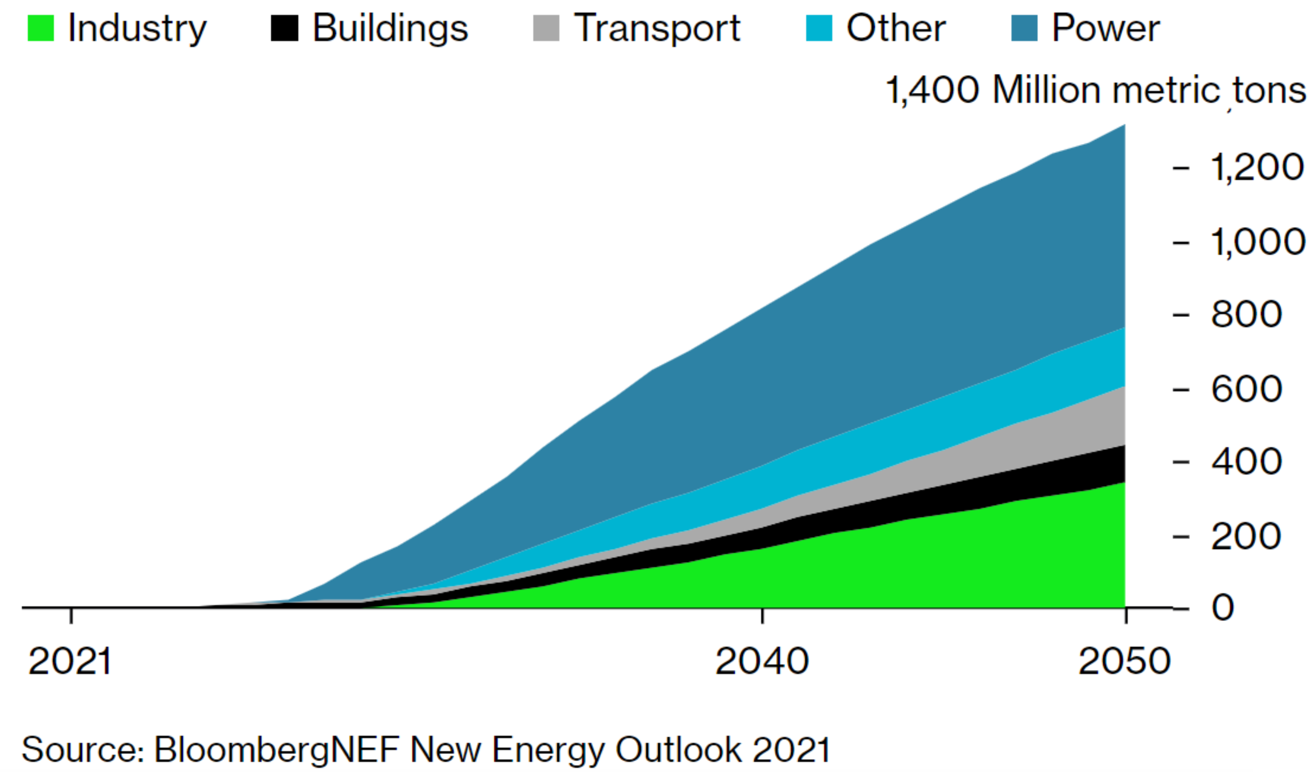
On the demand side of China's nascent green hydrogen market, Baowu, the world's largest steelmaker, has helped organize a global alliance of steelmakers committed to lower emissions.[57] As part of its push to increase hydrogen use in its operations, Baowu has started building a hydrogen-enriched carbon-recycling blast furnace in western China.[58]

The potential payoff for early action on green hydrogen by Chinese enterprises derives from its steadily improving outlook. Global demand for hydrogen is taking off after growing steadily for years. Global hydrogen demand has increased threefold since 1980, from less than 20 million tons to more than 70 million tons annually in 2018.[59]

BloombergNEF estimates hydrogen demand could top 1,300 million tonnes by 2050, as shown in Figure 3, with hydrogen growing to around 22 percent of total final energy consumption, assuming global decarbonization investments needed to limit warming to below 2 degrees Celsius.[60]

[vii] Curtailment is the technical term used for forgone potential output from a renewable power source. Curtailed renewable electricity is power not fed into the grid due to a mismatch in system supply and demand, which may come about because of low consumer demand at nighttime and limits to current battery capacity and other types of electricity storage. Putting such otherwise unused power to work producing hydrogen would make better use of low-carbon energy resources.

Figure 3. Global hydrogen demand outlook with actions needed to limit warming to 2 degrees Celsius[61]



CONCLUSION

Broader industry coverage is an essential next step for China's ETS to serve its intended role as a pillar of the country's decarbonization strategy. The delayed and uncertain schedule for expanding the CN ETS to additional industries reflects informational and related political economy challenges. This report recommends a three-step approach to overcome obstacles to expanding industry coverage under the CN ETS. First, the MEE should address competitiveness concerns by introducing a price collar. Second, the MEE should embrace benchmark simplification, reducing allocation benchmarks to the minimum viable number, aiming for one per unique product. Third, the MEE should spotlight the growing clean tech opportunities for industries added to the CN ETS and build understanding of how these outcomes align with national economic strategy. Such economic advantages are currently underappreciated and spotlighting them will help smooth the path for expansion and strengthening of the CN ETS.

APPENDIX. GLOSSARY

Term	Definition
Allocation benchmark	An allocation benchmark sets the quantity of free allowances that firms receive per unit of output produced.
Competitiveness	The ability to compete successfully with other companies or countries.
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.[62]
Leakage	The potential for more stringent regulation to cause shifts in production or investment to other countries or areas with fewer constraints on emissions. Should it occur, leakage results in fewer emissions reductions than intended and leads affected producers to lose market share to more emissions-intensive competitors.
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.

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