China's CO_2 Emissions Trading System: History, Status, and Outlook[1]

Valerie J. Karplus
Carnegie Mellon University

June 2021

China's emissions trading system (ETS) for carbon dioxide (CO_2) will become operational in mid-2021. The system targets reductions in carbon intensity via a tradeable performance standard, initially in the power sector, with expected expansion to other industries. Plans to convert from a rate-based to a mass-based system are underway. This paper describes the trading system's history, design, rules governing implementation, and anticipated developments over the next decade. The ETS is expected to incentivize about half of the reductions needed to reach peak CO_2 emissions by 2030 and to support China's goal of reaching carbon neutrality by 2060.

1. Introduction

The past decade has seen the gradual development of an emissions trading system (ETS) for carbon dioxide (CO_2) in China. Emissions trading forms the cornerstone of China's greenhouse gas (GHG) emissions reduction efforts. While plans to begin trading currently exist only for the power sector, at full scale the system will cover eight major energy-intensive sectors. Ultimately, the system is expected to cover 72% of the country's CO_2 emissions by 2025 (Zhang, 2021). If the power sector begins trading as expected in 2021, global GHG emissions under existing or planned carbon pricing systems would increase by roughly 40%, relative to 2020 levels (World Bank, 2020).

An ETS allocates to enterprises rights to emit and allows market participants to purchase these rights when doing so is cheaper than undertaking reductions internally. Economists consider an ETS a least-cost policy because trading theoretically equalizes the cost of an additional unit of emissions reduction across emitters, staying below the total emissions limit at least cost.

China's policymakers have embraced emissions trading to advance multiple objectives. First, the ETS is widely viewed as a cost effective tool for controlling CO_2 emissions from its major sources in electric power and industry, providing a mechanism to implement China's contribution to global climate change mitigation. However, cost effectiveness is not the only goal. Second, an ETS builds *government capabilities* in monitoring, reporting, and verification (MRV) of CO_2 emissions, which is necessary to measure progress toward national climate goals and to strengthen trust in the system's efficacy among both participants and observers. Third, the ETS *gives new life to China's CO_2 offset market*, which previously relied on selling certified emissions reductions to the European Union Emissions Trading System (EU ETS). Fourth, and

[1] The author is grateful to Marika Tatsutani for editing the paper and to Bryan Galcik for layout and design of the document.

perhaps most importantly, the system *holds emitters responsible* for the CO_2 they emit. It provides the basis for holding managers accountable for CO_2 and other GHG emissions, in the same way that earlier policies targeted local environmental pollutants. Arguably, China's policymakers could implement many alternative policy designs that could help to achieve these ends, but none shares the sectoral coverage, local familiarity and support, international stature, and alignment with China's domestic market reform agenda of an ETS. While the ETS will help to equalize the marginal cost of CO_2 abatement across firms, this is far from the sole criterion on which China's policymakers are judging the success of the system.

China's gradual approach to developing its ETS reflects challenges that have emerged and lessons learned along the way. The proposal to use emissions trading to manage CO_2 emissions in China was first announced in 2011 and piloted in seven provinces and cities starting in 2013. At the end of 2017, authorities officially announced the launch of efforts to build China's national ETS. After several years of preparation and delays, trading in the first covered sector, electric power, is expected to commence by June 2021. Challenges related to establishing monitoring, reporting, and verification (MRV) protocols for targeted industries, transitioning responsibility for climate change policy from the National Development and Reform Commission (NDRC) to the newly created Ministry of Ecology and Environment (MEE) in 2018, and, most recently, COVID-19 have meant a longer road for China's ETS. However, delays have also allowed time to lay a stronger ideological, legal, and technical foundation for its eventual launch.

This paper reviews the status of China's ETS. Section 2 provides historical context. Section 3 describes how China's ETS is currently implemented as a tradeable performance standard (TPS), with reduction obligations benchmarked to output. Section 4 describes the implementation of the ETS, elaborating its administration, coverage, and provisions for MRV and compliance. Section 5 addresses interactions with existing policies, including the relationship between preexisting regional pilots and the emerging national system. Section 6 assesses future directions for system development. Section 7 concludes.

2. Historical Context

China's ETS is designed to support the implementation of national climate change mitigation goals. When policymakers first introduced targets for CO_2 emissions intensity in the Twelfth Five-Year Plan (2011–2016), an ETS began to gain traction as a cost-effective alternative to command-and-control approaches for addressing climate change. National targets for reducing CO_2 emissions intensity, or CO_2 emissions indexed to output, correspond to mitigation commitments pledged as part of the United Nations Framework Convention on Climate Change (UNFCCC) process. The country's first pledge in Copenhagen in 2009 committed to reducing national CO_2 intensity by 40%–45% by 2020, relative to 2005 levels. Ahead of the 21st Conference of Parties (COP) in Paris in 2015, China's leaders announced intentions to reduce the CO_2 intensity of China's economy by 60%–65% below 2005 levels by 2030, and to reach peak CO_2 emissions at the latest by 2030. In the fall of 2020, President Xi Jinping announced before the UN General Assembly that the country would aim to achieve CO_2 neutrality by 2060.

China's ETS builds on experience with seven pilot emissions trading systems for CO_2 that launched in 2013–2014. Prior experience with industrial energy efficiency programs, the Clean Development Mechanism of the Kyoto Protocol, and early experiments with sulfur dioxide (SO_2) trading in the late 1990s have also informed and shaped the design of China's ETS.

Table 1. Correspondence between national climate pledges and key domestic CO_2 reduction policies.

Pledge Year	National Climate Pledge – CO_2 Reduction Target and Time Frame	Key Implementing Policies
2009	Reduce CO_2 intensity 40%–45% by 2020, relative to 2005	National and provincial CO_2 targets, industrial energy efficiency targets, ETS proposed
2014	Reduce CO_2 intensity 60%–65% by 2030, relative to 2005; reach peak CO_2 emissions by 2030	Regional ETS pilots, national ETS (rate-based), support for renewable electricity deployment and integration
2020	Achieve CO_2 neutrality by 2060	National ETS (mass-based), renewable portfolio standards, R&D support for low-carbon energy, technology standards (non-CO_2 GHGs)

China initially developed the ETS as a way to support the achievement of national and provincial targets for CO_2 intensity, in line with the national pledges and alongside other supporting policies, as described in Table 1. During the Twelfth Five-Year Plan, CO_2 intensity targets were introduced alongside energy intensity targets to support domestic implementation of the 2009 Copenhagen pledge. Energy intensity targets had long been included in the country's Five-Year Plans, but starting only with the Eleventh Five-Year Plan (2006–2010) were these targets considered binding. In particular, a costly scramble at the end of the Eleventh Five-Year Plan to achieve "mandatory" energy-intensity reduction targets highlighted the consequences of inflexible targets. Officials disaggregated the national target to subordinate administrative levels, with targets assigned at the provincial and lower levels to achieve distributional equity objectives. In general, less developed western provinces faced less stringent targets, compared to the more developed East.

Responsibility for climate change, and thus ETS development, initially belonged to China's National Development and Reform Commission (NDRC), the state's main economic planning body. In 2018, functions related to climate change were transferred to the Ministry of Ecology and Environment (MEE), which oversees the regulation of domestic air, water, and soil pollutants. This transfer of responsibility authorizes MEE to monitor GHGs alongside other pollutants at the enterprise level, oversee the ongoing implementation of the national ETS, and punish non-compliance.

Key dates in the development of China's national ETS include:

2011	Plans to develop trading systems for CO_2 emissions announced
2013–2014	Seven ETS pilots launched
Dec. 2017	National ETS development launched, roadmap outlined and endorsed by the State Council
2018	Responsibility for climate change and the ETS transferred from the NDRC to MEE
Dec. 2021	*Administrative Measures for Carbon Emission Trading* (Trial) published (effective February 1, 2021)
Feb. 2021	*Interim Regulation for the Management of Carbon Emissions Trading* (Draft) published

3. ETS Design: A Tradable Performance Standard

3.1 Permit Allocation

China's ETS is essentially a tradable performance standard (TPS): it targets reductions in the CO_2 intensity of economic activity (a rate-based system), rather than total CO_2 emissions (a mass-based system) (Pizer and Zhang, 2018). The TPS targets reductions in the average CO_2 emissions per unit of output of covered facilities. A TPS requires that covered entities regularly provide information on both covered emissions and economic output. At the end of the compliance period, regulators adjust final allowance allocations up or down based on the verified output of facilities.

Large firms in eight sectors – electricity (including power generation and power and heat cogeneration), buildings, iron and steel, non-ferrous metal processing, petroleum refining, chemicals, pulp and paper, and aviation – are slated for inclusion in China's national ETS when it reaches full scale. Applying a threshold of approximately 26,000 tons CO_2 emissions per year, corresponding to verified energy use of 10,000 tons of coal equivalent, at full scale the program is expected to cover approximately 7,500 enterprises representing 6.7 billion metric tons (bmt) of CO_2 or 72% of China's total CO_2 emissions in 2017 (Zhang, 2021). China's fossil power generating units are essentially all above this emissions threshold and therefore the ETS is expected to achieve comprehensive coverage of the sector, which emitted a total of 3.6 bmt of CO_2 in 2017.

In electric power, the first sector to implement the ETS, initial permit allocations differ according to the CO_2 emissions rate determined by a unit's technology. The system defines four benchmark categories: conventional coal plants below 300 megawatts (MW), conventional coal plants above 300 MW, unconventional coal, and natural gas. Benchmarks are intended in part to limit the

burden on older, dirtier plants by comparing their performance to the best-in-class efficiency of a comparable plant. As these plants are disproportionately located in less affluent, often central and western, provinces, the benchmarks provide a way to address regional equity concerns. Earlier iterations of the ETS included up to 11 benchmarks (Pizer and Zhang, 2018), but the number was ultimately reduced with the goal of raising the overall efficiency of the system.

An open question is how provincial governments will handle the uncertainty in provincial emissions reduction obligations created by a national trading system. The national ETS will cover only a subset of emitting firms in each province, including all electric power generators and firms representing between 50–100% of the emissions in other energy-intensive industries. In particular, a number of smaller emitting firms in the cement industry will not be covered by the national system. Within energy-intensive industries, firms below the threshold for inclusion in the ETS are often comparatively CO_2-intensive. Provincial governments subject to targets will need to determine how much CO_2 intensity reduction effort should come from installations in the province that are not covered by the ETS. This amount is uncertain because the CO_2 reductions by ETS firms, and the relative reliance of ETS installations on in-province reductions versus on allowance purchases and offsets, will not become known until the end of the compliance period. This will create difficulty for provinces when designing supplementary measures to support CO_2 intensity target achievement. It will also be a challenge to ensure that offsets generated in or outside the province are not double-counted toward provincial CO_2 intensity reduction goals.

3.2 Abatement Strategies

The tradeable performance standard design has implications for covered entities' abatement choices. Consider its implications for firms in the power sector, the first sector to be covered by the ETS. Firms essentially have two ways to comply: improve the efficiency of individual facilities and shift generation among units (e.g., from less efficient, often older and smaller, units to more efficient, typically newer and larger, units). Given that benchmarks are defined separately for coal and natural gas facilities, there is limited incentive for fuel switching. Coal to natural gas switching was one of the major compliance strategies observed in the EU ETS. Natural gas is included in a separate benchmark category to avoid an outcome in which these units receive large permit surpluses. Since allowance allocations adjust based on actual output, only units with emissions intensity below the benchmark will have incentives to reduce CO_2 emissions by curtailing output. Facilities that find it too costly or difficult to comply will face increased pressure to shut down permanently.

The ETS does not cover non-fossil electricity generators (e.g., nuclear, hydro, and renewables). Instead, policies such as renewable portfolio standards will separately target increases in renewable generation. Mandates to expand renewable energy are likely to limit the contribution of fossil generation, and thus the ETS will apply to a decreasing share of overall power sector output in the coming decades.

4. ETS Implementation

This section describes the planned implementation of China's ETS, based on relevant laws and directives released as of May 2021. The primary focus is on the design as it applies to the power sector, which is scheduled to begin trading by June 2021, recognizing that the extension of CO_2 trading to other sectors is still under development.

4.1 Institutional Structure and Administration

The Ministry of Ecology and Environment and its subnational representative offices oversee the implementation of China's national emissions trading system. Effective on February 1, 2021, the "*Administrative Measures for Carbon Emission Trading* (Trial)" (hereafter "*Administrative Measures*"; link provided in full references) published by MEE outlines the rules governing system implementation. The document begins by stating several principles to guide the development of the ETS, including adherence to: market orientation, gradual progress, fairness and openness, and honesty and trustworthiness. Opening keywords are a typical feature of policy guidance in China – they are designed to create a shared set of expectations among stakeholders on process design and outcomes.

The *Administrative Measures* outlines a role for two national agencies in program administration. First, the National Carbon Emissions Rights Registration Agency will record holdings, modifications, payments, and retirements of emission allowances using the national carbon emission rights registration system. It will also provide settlement services. Second, the National Carbon Emissions Trading Agency will oversee the centralized exchange of allowances among market participants. Previously, it was unclear whether one of the exchanges for the carbon market pilots would assume this function, but the *Administrative Measures* clearly establishes one national authority. Both agencies will regularly provide status updates to the MEE.

The MEE itself is in charge of outlining rules regarding the technical definition of emissions reduction, overseeing the performance of local (e.g., provincial and municipal) offices involved in supervision and management of the carbon emission quota allocation, requiring GHG emissions reporting and verification, and cooperating with the relevant departments of the State Council on ETS coordination. The transfer of program leadership from the NDRC to the MEE after 2018 contributed to delays in implementation.

Authorities at various levels of government are responsible for specific elements of ETS implementation, as spelled out in the *Administrative Measures*. Overseen by the national MEE, its provincial offices are responsible for allocating and collecting payments for purchased emissions allowances, verifying GHG emissions reported by firms, and carrying out supervision and management functions locally. Municipal EE authorities may be directed to carry out these functions by their provincial overseers.

By the end of 2021, a State Council Regulation is expected to provide a stronger legal basis for the emissions trading system as part of the country's effort to address climate change. Such a

regulation is equivalent in strength to a law passed by the National People's Congress. It would lay a foundation for future development of the system, including the introduction of higher penalties for non-compliance. The *Interim Regulation for the Management of Carbon Emissions Trading* (Draft Revision), published on March 30, 2021 and hereafter "*Interim Regulation*" (link provided in full references) would supersede the *Administrative Measures* if it goes into effect later this year. Unless otherwise stated, the ETS description below relies on the *Administrative Measures*.

4.2 Allowance Allocation

The MEE determines the total carbon emissions quota and plans for allocating allowances. Allowance allocation in China's national ETS considers national GHG emissions control requirements (set forth in the national and provincial targets), economic growth, economic structure adjustment (reduction of emissions by increasing the share of less energy intensive industries), energy structure optimization (reduction of emissions by switching to low carbon fuels), and coordinated control of air pollutant emissions. While the intensity basis of the allocation accommodates economic growth, other criteria are not considered explicitly. Despite ongoing interest in using the ETS to reinforce air pollution control objectives, there is no consensus yet on whether or how these objectives could be incorporated into program design.

The Allocation Plan involves granting covered units a pre-allocation of permits, based on historical CO_2 emissions levels and output, followed by *ex post* adjustments. *Ex post* adjustments grant allowances for emissions indexed to actual output, while allowable emissions are calculated based on the performance of each category's benchmark emissions control technology. In the initial phases of the program, allowances will be allocated free of charge. However, both the *Administrative Measures* and the *Interim Regulation* suggest that the system will increasingly shift from free to purchased allowances over time.

Quota setting in China's initial phase of the ETS in the power sector takes into account both power and heat generation, which sum together to form a unit's total emissions permit allocation. Quantities of power or heat produced are multiplied by the respective benchmark values for allowable emissions rates. Subsequent adjustments account for cooling mode (air cooling, water cooling), the relative share of heating, and the average load. In particular, plants that use air cooling, which is less water intensive, are entitled to an allowance multiplier on the electricity portion of their output of 1.05, compared to 1 for water cooling.

4.3 Scope and Coverage

The first phase of China's emissions trading system will include 2,200 companies in the power sector, including combined heat and power (CHP) and on-site generators. Covering the power sector only, the system will regulate 4 bmt of CO_2 emissions annually, 40% of China's total national CO_2 emissions. Proposals to expand the system to cement and aluminum are under development. Trading in these sectors is expected to begin sometime in 2022.

In addition to units covered by the ETS, the MEE is responsible for monitoring emissions from all "Key GHG Emitting Units" with the expectation that these units will eventually be covered

under the national ETS. A Key GHG Emitting Unit is any unit that exceeds the threshold for inclusion in the ETS (26,000 tons of CO_2-equivalent emissions per year) and belongs to one of the eight ETS sectors. This designation is similar to that used to designate large emitters of local pollutants. Previously, lists of key emitters of specific pollutants – such as SO_2 or nitrogen oxides (NO_x) – defined the scope and targeting of major environmental regulations. Units for which annual GHG emissions have not reached 26,000 tons CO_2-equivalent for two consecutive years, or that have closed, shut down, or are no longer producing exit the ETS.

According to the *Administrative Measures*, up to 5% of the quota can be satisfied with voluntary emission reductions that are external to the trading system. Example sources of voluntary emission reductions include the development of domestic renewable energy, forest carbon sinks, methane utilization, and other domestic projects. All voluntary emission reductions must be registered in the national voluntary emission reduction transaction database. How to ensure that these voluntary reductions are not double counted toward the ETS and related policies, for instance provincial renewable portfolio standards, remains an open question.

4.4 Monitoring, Reporting, and Verification

The functionality of a national ETS is only as strong as its ability to account accurately for the CO_2 emissions of covered units. MRV establishes units' historical CO_2 emissions and emissions intensity. It also measures changes over time. In the seven ETS pilots, the measures implemented to support high-quality MRV varied widely. Arguably, MRV was most developed in Beijing among the seven ETS pilots. The Beijing government required additional random audits of emissions reports prepared by official third-party emissions verifiers. Research suggests that under this system, firms' self-reported emissions deviated widely from actual emissions in the initial years of the program. These deviations occurred in both directions, suggesting that firms did not deliberately misrepresent their emissions (Zhang et al., 2019). The need to examine how MRV could be expanded to support the nationwide ETS, especially given provincial and sectoral variation in incentives and institutional capacity, contributed to the gradual pace of system development. The *Administrative Measures* directs officials to use the "double random, one public" approach to inspection and supervision, a general practice advocated by China's regulatory agencies that involves randomizing the match between verifiers and covered firms ("double random") and publishing the verification results ("one public"). More than 400 emissions verifiers are certified to serve firms in the national ETS. Units that apply for inclusion in the ETS must first have their emissions verified and then approved by the provincial EE authority.

4.5 Enforcement and Non-compliance Penalties

Current enforcement mechanisms, including non-compliance penalties, must carefully balance incentives to deter non-compliance with the need to maintain the cooperation of market participants. The *Administrative Measures* state that falsely reporting or concealing emissions results in a fine of not less than 10,000 yuan but not more than 30,000 yuan, which is modest compared to the annual profit of most covered firms. If allowances are not surrendered on time and in full, local authorities may impose a fine of 20,000 to 30,000 yuan. The allowable fine is expected to rise if a final version of the State Council's *Interim Regulation* is issued. According

to the *Interim Regulation*, falsely reporting or concealing emissions would result in a fine of not less than 50,000 yuan but not more than 200,000 yuan. Failing to surrender sufficient carbon emissions allowances owed at the end of the compliance period would carry a fine of 100,000 to 500,000 yuan. However, financial penalties are not expected to be the only deterrent for non-compliance, relative to other tools that provinces can use, such as restricting access to financing or other forms of assistance to firms. If emissions verification organizations collude with covered firms or falsify data, penalties include cancelling the commission, impairing its credit record, and in serious cases prohibiting the organization from operating for three years. Ongoing discussions focus on how provincial leaders and firms could be punished in annual performance reviews for failing to comply with ETS rules.

5. Interactions with Related Policies

To some extent, China's landscape of climate policies can be described as adopting a "belt-and-suspenders" approach. The ETS layers on top of the seven official pilot ETS programs as well as a range of sectoral climate and industrial policies. It is therefore important to have a clear understanding of how these policies will interact with and ultimately affect total CO_2 reductions in line with China's pledge to achieve carbon neutrality by 2060.

5.1 Pilot Trading Systems

An important question for the national ETS is whether it would supersede the seven official ETS pilots established in Beijing, Tianjin, Shanghai, Guangdong, Shenzhen, Hubei, and Chongqing. The pilots vary in sectoral coverage but would overlap substantially with the national ETS once it becomes operational in the eight covered sectors. The latest rules suggest that the pilots will continue to coexist alongside the national system but these systems will not overlap. Specifically, the *Administrative Measures* specifies that once a unit is included in the national system, it must exit any pilot system to which it belonged. However, provincial authorities are free to expand pilot systems to below-threshold firms and firms in uncovered sectors as a means of supporting the achievement of provincial CO_2 intensity targets.

5.2 Renewable energy policy

Renewable portfolio standards, set by province, have replaced feed-in tariffs as the primary policy instrument for promoting renewable energy within China's electricity mix. The ETS as it is currently developing in the power sector covers only fossil energy (mainly coal and natural gas generation), with emission reduction obligations defined at the unit level. As a result, renewable energy obligations and the ETS for the most part do not overlap. For power generators in the ETS, deploying renewable energy is not available as a strategy for reducing CO_2 emissions under the system. The only potential overlap occurs in the category of offsets, which can cover up to 5% of a firm's reduction obligation. Here, renewable energy purchases can count towards allowable offsets, raising the possibility of double counting under the ETS and renewable portfolio standards. This issue remains to be clarified in future iterations of system design.

5.3 Industrial energy efficiency policy

Industrial energy efficiency programs targeting large firms, including the Top 1000 Enterprises Program (2006–2010) and Top 10,000 Enterprises Program (2011–2015), were in many respects precursors to a multisector national ETS. While these programs did not include trading, they similarly targeted large energy users – which, given China's high share of coal use in electricity and in direct industrial uses, is a close proxy for CO_2 emissions intensity. These programs also underscored for policymakers the importance of strong MRV, due to concerns that emerged about the reliability of self-reported data submitted for compliance purposes under these programs.

The latest iteration of these industrial energy efficiency programs overlaps very closely with the expected scope of the national ETS. In its latest iteration, an expanded energy efficiency program has introduced energy-saving allowance trading on a pilot scale. This overlap with the ETS is problematic because firms that must reduce energy use intensity within their own boundary will have limited incentives to engage in trading. Moreover, firms will need to keep track of closely related compliance obligations for energy and CO_2, which could nearly double overhead requirements. Since these two closely related programs are led by different government departments (the NDRC and the Ministry of Industry and Information Technology oversee implementation of the industrial energy efficiency programs), resolving this overlap will be challenging but ultimately important to the effective operation of an expanded national ETS.

6. Looking to the Future

6.1 Scaling the system beyond electric power

An important question concerns how fast, and in what order, to expand the coverage of the ETS to other sectors. ETS architects have focused on several criteria. First, is MRV complete for the key emitting entities in the sector that would be included? This is not straightforward, given that MRV functions are implemented at the provincial level, and both local EE offices and covered units are conducting MRV for the first time. Therefore, national oversight must observe and correct for erroneous accounting practices. Carrying out MRV has proven more straightforward in sectors with relatively homogeneous products, such as cement and aluminum smelting, leading these sectors to become next in line to begin trading under the national ETS.

Second, a lesser extent of state ownership outside the electric power sector may improve the efficiency of system operation, as private firms may be more responsive to costs imposed by the ETS. However, these firms may be less accountable to state oversight bodies, as non-state firms lack direct channels such as the target responsibility system, which shape the incentives for top leaders. In the context of China's industrial energy efficiency policies, larger, non-state firms were more likely to report non-compliance (Karplus et al., 2020).

6.2 From a rate-based to a mass-based system?

The architects of China's ETS have indicated that it will eventually move from a rate-based system (TPS) to a mass-based system. A mass-based system would remove the implicit output subsidy, raising the cost-effectiveness of CO_2 reductions. The incremental cost of the TPS rises with the total emissions reduced as, under a mass-based ETS, reductions in electricity output contribute a greater share of total CO_2 abatement (Goulder et al., 2017; 2019). The major drawback of transitioning to a mass-based system is that the rate-based system has strong support among those concerned about limiting the burden of the ETS on covered firms and, more broadly, economic growth.

6.3 Impact of ongoing power market reforms

China's ongoing electric power sector reforms directly interact with the first phase of ETS operation, which covers only power generating units. From 1998 to 2003, an initial round of reform separated generation and transmission, and broke up the state's monopoly over generation, with the goal of attracting new investment to meet rapidly growing demand and address shortages (Davidson and Pérez-Arriaga, 2020). Since 2016, the focus of reforms has shifted to the dispatch mechanism along with wholesale and retail pricing, with the goals of (1) reducing electricity prices, (2) providing appropriate incentives to invest in ancillary services to ensure continuous system operation, and (3) improving the grid integration of renewable energy, including via transfers across provincial boundaries.

China's system of fixed electricity pricing has evolved into a mixed system comprised of "within plan" (fixed) pricing and transactions that occur in bilateral markets, multi-sided markets, and spot markets. As of the end of 2020, eight provinces/regions had been selected for spot market pilots: Southern China (Guangdong), Western Mongolia, Zhejiang, Shanxi, Shandong, Fujian, Sichuan, and Gansu. Spot prices in these pilots were initially very low, closer to the variable cost of the coal units in these areas. These reforms have resulted in provincial variation in the share of electricity sold that is subject to market-based pricing. This presents a challenge for uniform implementation of the ETS, because firms subject to "within plan" pricing are unable to pass through ETS compliance costs, placing them at a disadvantage relative to those that sell part or all of their generation into markets.

6.4 International climate policy and linkages

As more countries seek to achieve climate neutrality by mid-century, linking climate policies internationally will offer governments the opportunity to reduce marginal GHG abatement costs while discouraging the relocation of energy-intensive, trade-exposed industries. In response to concerns over carbon leakage, border carbon adjustments (BCAs) are already under development in Europe, and have reemerged as a key element in recent discussions of policy design in the United States. BCAs can provide a starting point for linkage because they require an assessment of the relative stringency of climate policy in export versus domestic markets. As more nations adopt climate policies and explore the use of BCAs, this assessment could form the basis for determining the gains from linkage.

In many respects, the architects of China's ETS are positioning the country to link its emerging system to others globally. First, China can build on experience with linkages through offsetting: in the early 2000s, before implementing its own national climate policy, China was a major source of CO_2 offsets for the EU ETS via the Clean Development Mechanism. The beneficiaries of offset sales have continued to advocate for the continuation and expansion of opportunities to gain credit for reductions, including under the national ETS as well as policies overseas. Second, linkage provides a channel for China to project its system design and technical standards onto newly developing systems around the world, while at the same time reinforcing its reputation as an engaged participant in global climate change mitigation efforts. Third, as China's ETS expands and low-cost emission-reduction opportunities grow more limited, system architects will have an economic incentive to pursue linkages as a way to contain rising costs of abatement. It also would offer Chinese firms with an opportunity to purchase credits to cover their domestic emissions.

7. Conclusion

Learning from prior experiences with environmental policy, China's policy makers have pursued a gradual path to developing both the emissions trading system and, in parallel, supporting institutions for MRV and enforcement. While the broader effort is labeled an emissions trading system, an in-depth look reveals that it is, at its heart, a transitional system that combines elements of enterprise-level targets, state control, and industrial policy with a market mechanism. Many see deviations from the market mechanism as necessary and important to gain buy-in, build experience, and address equity concerns, especially at the outset.

Over time, parallel developments – in electricity market reform, reductions in the cost of renewable and other advanced energy technologies, and stronger, more geographically even MRV and enforcement capabilities – are likely to contribute to less costly, and more efficient, system operation. As such, future incarnations of the ETS have the potential to be a formidable tool for managing the CO_2 impact of covered industries. China's ETS is also likely to serve as an example for other developing country governments that are seeking cost-effective paths to mitigate their own contributions to climate change.

Global climate mitigation efforts will need to consider all greenhouse gases, not just CO_2 (which accounts for approximately 80% of China's total GHGs). They will also have to grapple with the fact that emissions do not stop at national borders, but rather result from the combined decisions of multiple actors in global supply chains. Currently, China's 2060 carbon neutrality goal does not mention other GHGs. Nor does it assume responsibility for GHGs emitted outside China's borders, even if these emissions are indirectly associated with Chinese companies or productive activities in China via their supply chains. The development of China's national ETS is a complement to, and not a substitute for, targeted efforts to address these broader challenges. A key question is how to evolve the ETS in a manner that encourages increasing levels of ambition over time.

References:

Administrative Measures for Carbon Emission Trading (Trial) 碳排放权交易管理办法（试行）published Dec. 30, 2020, effective Feb. 1, 2021 http://www.gov.cn/zhengce/zhengceku/2021-01/06/content_5577360.htm

Davidson, M. R. and Pérez-Arriaga, I., Avoiding Pitfalls in China's Electricity Sector Reforms. *Energy Journal*. 41 (2020). https://doi:10.5547/01956574.41.3.mdav

Goulder, L. H. and Long, X. and Lu, J. and Morgenstern, R. D., China's Unconventional Nationwide CO_2 Emissions Trading System: The Wide-Ranging Impacts of an Implicit Output Subsidy (2019). NBER Working Paper No. w26537. https://www.nber.org/papers/w26537

Goulder, L. H., Morgenstern, R. D., Munnings, C. and Schreifels, J. China's national carbon dioxide emission trading system: An introduction. *Economics of Energy and Environmental Policy*. 6, 1–18 (2017). https://doi.org/10.5547/2160-5890.6.2.lgou

Interim Regulation on the Management of Carbon Emissions Trading (Draft Revision). 碳排放权交易管理暂行条例(草案修改稿）published March 30, 2021. http://www.mee.gov.cn/xxgk2018/xxgk/xxgk06/202103/W020210330371577301435.pdf

Karplus, V. J., Shen, X., and Zhang, D., Herding Cats: Firm Non-Compliance in China's Industrial Energy Efficiency Program. *Energy Journal*. 41 (2020). https://10.5547/01956574.41.4.vkar

Pizer, W. A. and Zhang, X. China's New National Carbon Market. *AEA Papers & Proceedings.* 108, 463–467 (2018). https://doi.org/10.1257/pandp.20181029

World Bank. 2020. *State and Trends of Carbon Pricing 2020*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/33809

Zhang, D. et al., Integrity of firms' emissions reporting in China's early carbon markets. *Nature Climate Change* 9 (2019). https://doi.org/10.1038/s41558-018-0394-4

Zhang, X. (2021). *The Role of Carbon Market in Achieving China's New Climate Goals* (mimeo). Beijing, China: Tsinghua University Institute of Energy, Environment, and Economy.