

Theory and Practice of China's Carbon Emissions Trading System

**— key issues in China's national ETS
and case study of Hubei pilot ETS**

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CALIFORNIA-CHINA CARBON MARKET

PROJECT INTRODUCTION

As of 2021, 30 emissions trading systems were in force globally, covering 16-17% of global greenhouse gas (GHG) emissions.¹ The finalization of the Paris Agreement rulebook for international cooperation through carbon markets has cleared the way for the expansion of emissions trading and carbon pricing worldwide.²

This project is a collaboration among researchers from two major jurisdictions engaged in emissions trading: China – with a rate-based emissions trading system commenced in 2021 that is the world’s largest by emissions covered; and California – which has operated an economy-wide greenhouse gas emissions trading system since 2012.

Researchers at Tsinghua University, the California-China Climate Institute, UCLA School of Law, and Wuhan University convened a series of projects and events to share ideas and best- practices and to discuss ways to improve the design and implementation of emissions trading systems. The accompanying reports, (i) *Key Governance Issues in California’s Carbon Cap-and-Trade System*; (ii) *The Theory and Practice of China’s National Carbon Emissions Trading System*; and (iii) *The Institutional Characteristics, Effectiveness and Experience of Hubei Pilot Emissions Trading System*, are key outputs of this collaboration, among which (ii) (iii) are incorporated into *Theory and Practice of China’s Carbon Emissions Trading System: key issues in China’s national ETS and case study of Hubei pilot ETS*. The project also included a series of private dialogues on various aspects of emissions trading system design, including on data quality; compliance; monitoring, reporting, and verification (MRV); auctions; allowance allocation approaches; offsets; and the use of financial instruments in carbon markets.

Our collaboration has been guided by the goal of improving understanding of the respective emissions trading systems in China and California. Moreover, it served to explore ways to improve environmental ambition, to ensure market integrity, and to improve the policy environment for climate action. Key design considerations discussed include, among other things, setting caps and benchmarks at appropriately ambitious levels, utilizing auctions and other measures to create an effective price

¹ See *Carbon Pricing Dashboard*, WORLD BANK (last visited Apr. 6, 2022), https://carbonpricingdashboard.worldbank.org/map_data. (“In 2021, these initiatives would cover 8.73 GtCO₂e, representing 16.1% of global GHG emissions.”); see also INT’L CARBON ACTION P’SHIP (ICAP), EMISSIONS TRADING WORLDWIDE: STATUS REPORT 2022, at 36–37, https://icapcarbonaction.com/system/files/document/220330_icap_report_rz_web.pdf.

² These are rules under Article 6 of the Paris Agreement agreed upon at COP26 in Glasgow. Simon Evans et al., *COP26: Key Outcomes Agreed at the UN Climate Talks in Glasgow*, CARBON BRIEF (Nov. 15, 2021), <https://www.carbonbrief.org/cop26-key-outcomes-agreed-at-the-un-climate-talks-in-glasgow>.

signal, establishing MRV and enforcement systems to ensure data quality and the integrity of emissions reductions, properly structuring offset programs, and channeling market revenues toward environmental objectives. Our dialogues included invaluable assistance from Chinese and California regulators and researchers involved in the design and operation of emissions trading systems.

As a closing note, we reiterate our firm belief in the importance of continued international collaboration on climate change policy. This work, we hope, will serve to make complex emissions trading systems more transparent to the world and to lay the groundwork for improving the effectiveness of climate change policy and regulation.

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CHAPTER ONE

INTRODUCTION

Carbon emissions trading system (ETS) is an important policy instrument for the international community to address climate change. As an important mechanism to price greenhouse gas emissions, ETS plays a key role in promoting a low-carbon structural transformation of economy and energy, which is adopted by an increasing number of countries and regions. A key feature of ETS is to define the property rights of carbon emissions. The authority determines the amounts of emissions and allowances, and firms obtain allowances from authority in a certain rule and trade them in a secondary market during the compliance cycle. In the end of compliance cycle, covered entities need to surrender the full amount of allowances equivalent to their emissions. As a result, ETS achieves emissions reduction target at a lowest cost by equalizing the cost of an additional unit of emissions reduction across emitters via a market mechanism.

As the world's largest developing country and carbon emitter, on one hand, China's carbon emissions continue to rise due to medium-high economic growth; on the other hand, China faces increasing international pressure due to the huge volume of emissions. Therefore, the difficulty and complexity of China's tackling with global climate change is unprecedented, requiring the promotion of low-carbon transformation in the whole society.

In September 2021, the State Council of China issued *“Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of The New Development Philosophy”*, proposing the “Leveraging the strengths of the government and the market” principle and emphasizing that accelerate the development of the national carbon market by gradually expanding coverage, diversifying trading types and means, and improving the allocation and management of allowances. Carbon market plays an important role in China's carbon peaking and neutrality. Under a carbon trading framework, China can achieve emissions reduction targets in a way that minimizes social cost, and promote low-carbon transformation of energy-intensive industries and the development of new energy industries. What's more, the implementation of the monitoring, reporting, and verification (MRV) system provides an important data basis for China's national climate goals and will promote the implementation of energy efficiency standards. Besides, China's ETS promotes voluntary GHG emissions reduction, which previously worked as certified emission reductions and almost sold to the European Union Emissions Trading System (EU ETS). ETS gives more flexibility to firms and the authority which makes it compatible with new and existing framework and provides an opportunity for international cooperation on climate change. Besides, its following principle of “polluter pays” allowing it to gain broader political acceptance.

In order to explore the design of China's carbon market, China released pilots in seven provinces and cities, namely Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Hubei and Guangdong since 2011. So far, each pilot has completed seven to eight years of compliance, with a cumulative turnover of nearly 10 billion yuan and an average transaction price of about 24 yuan/ton. Among them, the carbon price in the Beijing carbon market ranks first in China, with the highest price exceeding 100 yuan/ton in 2020. At the early stage of the pilot ETS, the imperfect system construction, insufficient experience of firms and government, insufficient capacity, and poor data base have resulted in cases such as ambiguous cap setting, over-issuance of allowance, low carbon price, and poor market liquidity. After proactive policy adjustment, these problems are gradually improved. The construction of pilot ETS has laid a good data and institutional foundation for national carbon market, which have raised the awareness and capacity of firms and the public, and cultivated the relevant talent teams, providing valuable experience for China's national carbon market.

China started preparations for national carbon market in 2015 and officially launched it in 2017. At the end of 2020, the Ministry of Ecology and Environment (MEE) successively released important policy documents on the administration of carbon trading, including *"The National Measures for the Administration of Carbon Emission Trading (Trial)"*, (hereafter *Administration Measures*), *"2019-2020 National Carbon Emission Trading Cap Setting and Allowance Allocation Implementation Plan (Power Generation Industry)"*, and *"Guidelines for Greenhouse Gas Emissions Verification (Draft Request for Comments)"* (revised and officially launched in March 2021), indicating China's national carbon market had designed basic elements of emissions trading system. In 2021, China's national ETS took the power generation sector as a breakthrough to carry out the first compliance cycle, and commenced trading in July with the first transaction traded at 53 yuan/ton.

The development of China's ETS has benefited from mature theories and advanced experience from international ETS, among which the representative ones include EU ETS, California emissions trading system and so on. This report introduces the context, principles and progress of China's national ETS along with a case study of Hubei pilot ETS, which we hope would be useful to other jurisdictions under consideration of ETS, especially developing countries.

CHAPTER TWO

DESIGN PRINCIPLES

The design of China's national ETS needs to incorporate economic theory and international experiences, but more importantly, it should fully consider China's current situation and develop a system with Chinese characteristics. China's national ETS needs to be aligned with the country's macro-economic goals, including carbon peaking, carbon neutrality, and high-quality development. It needs to balance short-term goals and long-term targets, equity and efficiency in the process of its development step by step. In addition, it should be coordinated with the electricity market reform and stay compatible with other international carbon markets.

A | The design of ETS should fully consider China's current situation

Research on cap-and-trade program started in the middle of 20th century and formed a mature framework of theoretical analysis. The European Union, California and other developed jurisdictions have been operating carbon markets for many years. The design of China's carbon market should actively learn lessons from these countries and regions, but should not copy their scheme, since there exist contextual differences.

First of all, differences exist in development stage. China would keep a medium-to-high speed of economic growth for a long period, while developed countries have entered the stage of low and stable economic growth.

Second, differences exist in commitment on climate change. China's international commitment on carbon emissions reduction is different from that of developed countries, which focuses on reducing carbon emissions intensity and peaking carbon emissions as soon as possible. While developed countries mainly commit to substantially reduce total carbon emissions, namely "absolute emissions reduction".

Third, the features of China's energy structure are different from those of developed countries. More than 70% of China's energy consumption comes from the industrial sector, while only about 30% of energy consumption is contributed by the industrial sector in developed countries. Over 50% of China's coal is used for electricity and heat production, and more than 70% of China's electricity and heat is used by the manufacturing sectors. In this context, a crucial issue arouses that users of electricity and heat are required to take sufficient responsibility for CO₂ emissions embodied in electricity and heat consumption.

Fourth, the market mechanisms are different. Developed countries have constructed mature electricity market, while China is undertaking electric power sector reforms

and its electricity and heat price are controlled by the government (mostly the Central Government) rather than a market-based fluctuant price. It is not only a challenge for effectiveness and efficiency of carbon market emissions reduction, but also causes controversial issue in sharing the responsibility of emissions reduction between electricity producers and consumers.

These unique national conditions in China dictate that the design of key elements of carbon market, such as coverage, cap setting, and allowance allocation, should be quite different from those of existing ETS.

B | China's national ETS needs to balance short-term goals and long-term targets, equity and efficiency

The construction of China's ETS is a long-term and complex job that needs constantly developing and improving. China's policy makers have pursued a gradual path to develop both the emissions trading system and, in parallel, supporting institutions for MRV and enforcement. It also requires to coordinate the relationship between the near-term and long-term, indicating that national ETS needs to be promoted in phase. The majority of existing ETS experiences phased construction. For example, EU-ETS is now in its fourth phase, with an increasing number of participating countries, industries and types of GHG, and the total amount of allowance and allocation schemes for each phase have also gone through a gradual improvement process.

By 2030 there have been three phases of China's national ETS. The first phase is 2015-2020, where national ETS is under preparation, with tasks to basically design the mechanisms, technical guidance and regulations. 2021-2025 is a phase that national ETS initially launched, aiming at commencing trading, expanding coverage, improving mechanism design and keeping the allowance price in a rational range. During 2026 and 2030, there would be more covered sectors and participants, benchmarks setting would be more stringent, and the national ETS would become a hybrid of mass-based and rate-based system.

The construction of China's national ETS should also coordinate the relationship between efficiency and equity, which mainly manifested in the fairness between industries and between regions. Expanding sector coverage gives consideration to equity between the covered and uncovered industries, and also helps to improve the efficiency of the carbon market. The issue about intra-industry equity, such as the sharing of carbon emission reduction responsibilities between the power generation sector and the electricity consumption sector, also needs to be fully considered. Considering that the risk of carbon leakage is different in covered sectors, EU ETS and California's carbon market gives flexibility to free allowances allocation to covered firms. For the equity between regions, construction of ETS should try to avoid the deterioration of income distribution between developed and less developed regions, and consider giving some support to less developed regions through offset mechanism

or transfer payment from auction proceeds. For example, California's carbon market has set up a special fund for managing auction proceeds, and uses most of the proceeds for consumer benefit rebates and emission reduction projects.

C | China's national ETS needs to be aligned with the country's macro-economic goals

The proposed carbon neutrality vision will accelerate the process of low carbon transformation of China's economy and energy. China's national ETS reflects the combination of an effective market and a responsible government, and would provide dynamic incentives for innovation and emissions reduction, which is intrinsically consistent with the goal of high-quality economic development. The fundamental purpose of carbon trading in China is to improve the total factor productivity, and thus negative economic effects is not expected. Therefore, a fixed cap of emissions is less political and economic appeal. The design of national carbon market should have advantages in incentivizing covered entities to improve energy efficiency, promote the elimination of backward production capacity, facilitate the technological upgrading of the industry, and accelerate the transformation of energy structure. Cap with flexibility to adapt to economic development and a scientific benchmark setting for industry is an appealing approach, which gives support to the high-quality development and the supply-side structural reform.

D | China's national ETS needs to coordinate with the electricity market reform

Carbon emissions mainly come from the production and consumption of coal, oil, natural gas, electricity and heat, and thus marketization of energy products has an important impact on effectiveness and efficiency of the carbon market. The power sector, which accounts for about 40% of China's total carbon emissions, is the largest carbon emissions sector in China, and plays a key role in China's national ETS.

The majority of existing ETS usually does not include indirect emissions from energy consumption side due to the repeated counting issues. Taking EU ETS as an example, who has a mature electricity market that can transmit the carbon price to electricity users through rise in electricity price, provides an effective incentive of electricity saving for consumers, and thus promote energy conservation in the whole society. While China's electricity and heat sector is still in the process of market reform, whose energy prices are mostly determined by government rather than the market, and the carbon prices cannot be fully passed from producers to consumers. Since about 70% of China's electricity is used in the industrial sector, indirect carbon emissions caused by users should also be considered when determining the emissions reduction target in the industrial sector, otherwise an important subject of emissions reduction will be ignored.

E | China's national ETS needs to stay compatible with other existing carbon markets

China's pilot ETS projects in 5 cities and 2 provinces provide valuable experience for the practice of China's ETS construction, whose coverage, threshold for inclusion, allowance allocation, enforcement and non-compliance penalties have great diversity. And the challenge emerges how the diverse pilots be incorporated into national ETS in the future. On one hand, covered entities in pilot ETS that meet the requirements should be included in the national carbon market; on the other hand, the pilot ETS should be allowed to operate until an effective incorporation plan is created.

As more countries seek to achieve climate neutrality by mid-century, linking climate policies internationally offers an opportunity to reduce globally marginal GHG mitigation cost, while discouraging the relocation of energy-intensive, trade-exposed industries. China has similarities with the vast number of developing countries in the world in terms of the environment and conditions for building carbon markets. Existing ETS should give help to developing countries to establish carbon markets and cooperation on carbon markets could be introduced into the framework of South-South climate change cooperation. In addition, China's national ETS should enhance cooperation with countries and regions that have already established or plan to establish carbon market, with whom to study and explore the feasibility of linking carbon market.

CHAPTER THREE

KEY FEATURES

At the initial phase, China's national ETS is a rate-based rather than a mass-based system. The allocation of allowances to firms in each sector is based on their actual output levels and corresponding benchmark emissions-output ratio, which should be an appropriate efficiency improvement target for that sector. China's national ETS is essentially a multi-sector tradable performance standard (TPS) and will serve as a tax or subsidy for firms with different emissions intensities. China chooses the TPS rather than a fixed cap for three reasons: first, the TPS is more appropriate for economies with faster growth as the output level is more uncertain; second, it is more politically appealing; third, it could be better aligned with China's near-term emissions reduction target, which is based on emissions intensity. Therefore, China's national ETS has a flexible emissions cap associated with actual output levels of covered sectors, rather than a fixed cap. The cap is also determined by choice of benchmarks, reflecting an idea of combining "bottom-up" and "top-down" in the cap-setting process. As China's electricity and heat sector is still in the process of market reform, carbon prices cannot be fully passed from producers to consumers. To incorporate consumers' emissions reduction responsibility and achieve their emissions reduction potential, China's ETS currently accounts for both direct emissions and indirect emissions associated with electricity and heat consumed by regulated firms.

A | Institutional structure and administration

Effective on February 1, 2021, *Administrative Measures* published by MEE outlines the rules governing system implementation. The "*Interim Regulation for the Management of Carbon Emissions Trading (Draft Revision)*" (hereafter *Interim Regulation*), published by MEE on March 30, 2021 would supersede the *Administrative Measures* once officially goes into effect. These two documents stipulate institutions and administration.

The MEE and its subnational representative offices oversee the implementation of China's national ETS. 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 National Development and Reforms Commission, Ministry of Industry and Information Technology, and National Energy Administration on ETS coordination. MEE shall propose the coverage scheme cooperated with other relevant national departments, and apply for approval of State Council. Provincial authorities of MEE take responsibility of allowance allocation, enforcement, MRV, and carrying

out supervision and management functions locally.

Two national agencies in program administration have established and take responsibility for registration and trade respectively. 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, whose specific work is now undertaken by Shanghai Environment and Energy Exchange, will oversee the centralized exchange of allowances among market participants. The two agencies are settled in Hubei and Shanghai respectively, required to regularly report to MEE.

B | Scope and coverage

The first compliance period of China's emissions trading system covers generator units with a threshold of 26,000 tons CO₂-equivalent, that is 2,162 companies in the power sector, including combined heat and power (CHP) and on-site generators. Covering the power sector only, the system regulates approximately 4 GtCO₂ emissions annually, about 40% of China's total national CO₂ emissions. Direct emissions from consumption of fossil energy and indirect emission from consumption of electricity and heat are both included.

China's national ETS plans to cover 8 energy-intensive sectors, namely electricity and heat, iron and steel, non-ferrous metal, construction material, petrochemical engineering, chemical engineering, and civil aviation, accounting for over 70% of total energy-related emissions. Approximately 8,500 entities from these sectors would be covered. Units belong to these sectors and subsectors that are also supervised by MEE and are required to submit GHG emissions report if exceeds the threshold for inclusion in the ETS. Proposals to expand the system to cement and aluminum are under development. Trading in these sectors is expected to begin sometime in second compliance period.

As for offset mechanism, up to 5% of the allowance can be satisfied with voluntary emission reductions that are external to the trading system according to the *Administrative Measures*. 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. The double counted problem toward the ETS and related policies is still under discussion and to be addressed. The sign and issue of certified voluntary emission reduction projects is under active preparation and the market is expected to restart soon.

C | Cap setting and allowance allocation

The MEE determines the total carbon emissions allowance and allocation plans.

Allowance allocation in China's national ETS takes account of greenhouse emissions target set in both national and provincial level, national and sectoral economic growth, economic structure and energy structure optimization, and coordinated control of air pollutant emissions.

China's ETS is essentially a tradable performance standard (TPS): it targets reductions in the CO₂ intensity of economic activity (a rate-based system), rather than total CO₂ emissions (a mass-based system). The allocation method of TPS is based on the performance of each category's benchmark emissions control technology and the actual 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.

In electric power industry, the first sector to implement the ETS, initial permit allocations differ according to the CO₂ 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. Following the principle of "encourage the advanced unit while phase out the backward ones", benchmarks are intended in part to exert an extra carbon tax on older, dirtier plants and give subsidy to the best-in-class efficiency of a comparable plant. The scheme of benchmarking is a trade-off between technological progress, improvement of power generation structure and phase out of lagging generators. Considering the provincial diversity of technology and economy, along with negative impact of aggressive reforms, earlier iterations of the ETS included up to 11 benchmarks to address regional equity concerns and to gain more political acceptance. While the number was ultimately reduced to 4, mainly considering the strengthened climate goal.

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 introduce purchased allowances in a proper time and gradually increase the proportion of purchased allowances, indicating that auction would replace grandfather over time. A national carbon emissions trading fund would be created to address to proceeds from purchased allowances in primary market, and the fund can only be used to support the construction of national ETS and important GHG emissions reduction projects according to the *Interim Regulation*.

D | Monitoring, reporting, and verification

The functionality of a national ETS is only as strong as its ability to account accurately for the CO₂ emissions of covered units. MRV system establishes units' historical CO₂ 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.

There are mainly three subjects in the mechanism, that is the covered units, technical service institutions and the authorities. The covered units are required to develop and implement monitoring plans, develop and submit annual emissions report in time (along with verification report). Provincial authorities shall verify monitoring plans submitted by entities, establish technical group and onsite team for verification, and draw the verification conclusion. It is remarkable that, the verifiers can consist of provincial authority, affiliated institutions and governments that purchase services from technical service institution. The covered units shall be responsible for the authenticity, completeness and accuracy of emission reports, and the provincial authorities shall be responsible for supervision.

The provincial authorities shall disclose and validate (if any) the verification conclusion, disclose and evaluate the performance of technical service institutions. 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.

CHAPTER FOUR

THE FIRST COMPLIANCE CYCLE

The first compliance cycle of China's national ETS has been officially started from 2021, covering the power generation sector as the first regulated industry, with 2,162 power generators covered. Up to December 31 in 2021, the first compliance cycle of China's national ETS has come to an end with a cumulative volume of 179 million tons of carbon emission allowances and a cumulative turnover of 7.661 billion yuan. The transaction price of carbon allowance mostly fluctuates between 40 and 50 yuan/ton with a highest price at 62 yuan/ton and an average price at 43 yuan/ton, with compliance covering over 99.5% of emissions. Based on the analysis of energy economy model of Tsinghua University, China's carbon price in the end of 13th Five-Year Plan is about 45 yuan/ton under a CO₂ emissions peaking before 2030 scenario, and thus the current carbon price meets expectation.



Figure 1: Trading Price and Volume of First Compliance Cycle

During the first compliance period of the national carbon market, there was an obvious cyclical fluctuation in the trading volume and price, with the quantity and price rising near the compliance date. Also, the quality of carbon market data needs further improvement and relevant laws and regulations are being constructed. It is remarkable that the first compliance cycle is a start-up before enters a stable operation stage, so it is inevitable that such problems as trading fluctuation, lack of liquidity and poor quality of emissions data will occur.

Overall, the first compliance period of the national carbon market has operated as expected. In addition to promoting energy saving and carbon reduction among the covered units, the formed carbon price signal will also influence the basis of asset pricing, which promotes low-carbon, zero-carbon and carbon-negative technology

investment and raises the awareness of low-carbon transition in the whole society. Problems emerged in the first compliance period also provide lessons for improving the policy design and enhancing the management of China's national ETS.

CHAPTER FIVE

OUTLOOK OF NATIONAL ETS

China's 2021 Central Economic Work Conference brought up that it is necessary to shift promptly from the dual control (total and intensity) on energy consumption to the dual control on carbon emissions. It indicates a heavier responsibility that China's ETS needs to bear, serving as an important grasp of dual control system for cutting emissions and carbon intensity.

During the 14th Five-Year Plan period, China's national ETS should strive to cover all the eight key energy-intensive and emission-intensive industries. It should set the cap and benchmarks following the "strictly controlling emissions increase" principle to facilitate carbon peaking before 2030. During the 15th Five-Year Plan period, sector and firm coverage of the national ETS should be further expanded. The cap setting and benchmark would be determined following the "steadily decreasing emissions" principle. The proportion of permits for auction should gradually increase, promoting the role of the national ETS in achieving China's carbon peaking and carbon neutrality targets. The architects of China's ETS have indicated that it will eventually move from a rate-based system (TPS) to a mass-based system.

MRV needs to be further improved based on material balance calculation, and simultaneously the application of continuous emission monitoring systems (CEMS) will be extended. Big data technology used to detect misreporting and manipulation is under research and will be apply to MRV soon. It is remarkable that MRV is a main concern when scaling the system, and it is 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.

In the future, institutional investors should be actively introduced to diversify trading subjects and to promote price discovery along with market activity, under a condition that China's national ETS operates stably with a mature spot market. Financial derivatives of China's CO₂ emissions allowances (CEA) are under discussed. It is noted that the relationship between the essential and financial attributes of the carbon market should be properly handled, and the carbon market should be fully recognized as a policy tool aimed at emissions reduction. The financial derivatives should be timely developed to diversifying trading types, while the risks and impacts should also be fully considered.

In terms of other carbon pricing mechanisms, carbon tax will be gradually introduced covering sectors and entities that are not included in carbon market, which helps to tackling with potential carbon leakage. The voluntary emissions reduction mechanism will be further developed in the future to meet the emissions reduction needs of

individuals and firms. The mechanisms jointly play a role in a market-based approach from multiple dimensions to form a reasonable carbon price. Besides, interactions with other climate policies (e.g., renewable energy policies and energy use rights trading policy) needs to be well coordinated.

CHAPTER SIX

THE INSTITUTIONAL CHARACTERISTICS, EFFECTIVENESS AND EXPERIENCE OF HUBEI PILOT EMISSION TRADING SYSTEM

As a traditional industrial and agricultural province, Hubei's economic development level and tertiary industry structure are representative in China. In November 2011, Hubei was selected as one of the seven pilot areas for emission trading system (ETS) in China. On April 2, 2014, Hubei pilot ETS was launched officially. In the following December 2017, Hubei took on the task of starting the construct of the national carbon emission registration and clearing system and the national ETS started to trade on July 16, 2021.

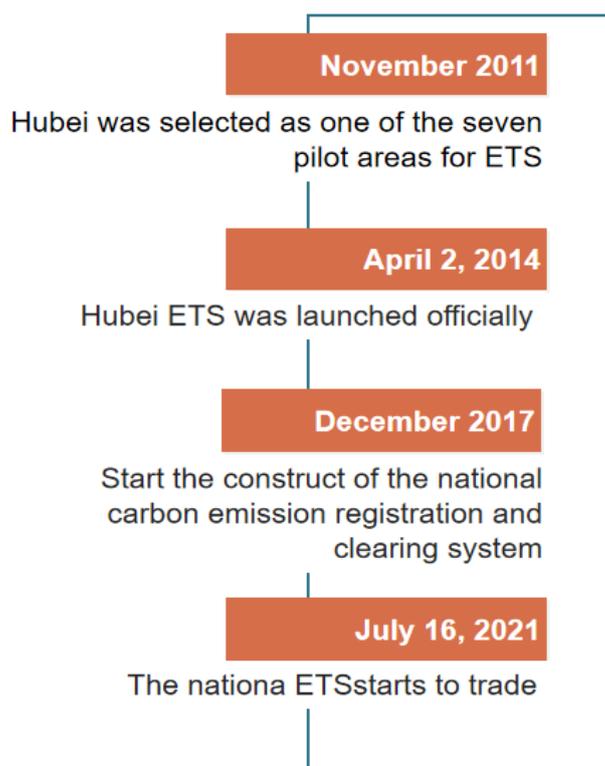


Figure 2: Background of Hubei ETS

After 10 years of exploration and practice, the pilot ETS in Hubei has proved that the ETS is an effective policy tool for the government to promote the transformation and upgrading of enterprises and control greenhouse gas emissions. The ETS has given full play to the decisive role of the market in resource allocation. The market-oriented

thinking of discovering carbon price through the market has been applied to government administration and business management. The ETS will also play an important role in promoting the goal of carbon peak and carbon neutralization.

A | Institutional Characteristics of Hubei ETS

Hubei ETS was launched in 2014, and there are 12,999 market entities, including 373 covered enterprises (industrial enterprises with annual comprehensive energy consumption of more than 10,000 tons of standard coal), 435 institutional investors and 12,191 individual investors, which is the most among all the seven ETS pilots. As shown in Figure 2, at present, the total carbon emission of covered enterprises is 273 million tons, accounting for about 45% of the whole province. The total output value is 1.1 trillion yuan, accounting for about 30% of the province and 70% of the secondary industry.

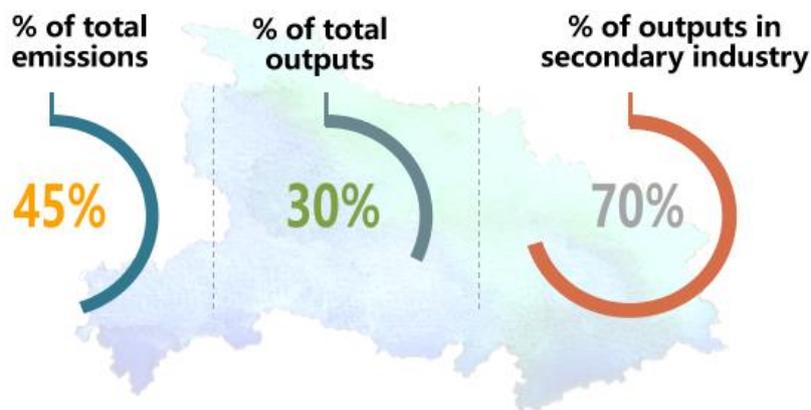


Figure 3: Proportion of Covered Enterprises within Hubei

Carbon emissions from the four major industries of iron and steel, chemical, electricity and cement accounted for 89% of the covered enterprises, among which their share is 20%, 10%, 39% and 20% respectively.

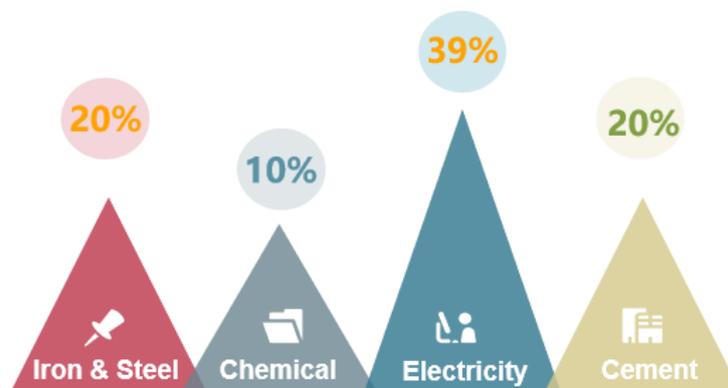


Figure 4: The Proportion of Carbon Emissions of the Four Major Industries

The ETS effectively covers greenhouse gas emissions from the industrial sector. The institutional characteristics of Hubei pilot ETS are reflected in the following aspects.

1 | Institutional system

A clear hierarchy system has been built. First, "Implementation plan of pilot ETS in Hubei" was released to clarify the general idea, main tasks and key job of the ETS construction in Hubei. The second was to formulate "five systems" based on "Interim measures for the management and transactions of ETS pilot in Hubei". "Allowance allocation scheme for carbon trading pilot in Hubei", "Rules for carbon emission trading of China Hubei Emission Exchange", "Guidelines for the monitoring, quantification and reporting of greenhouse gas emissions in Hubei" and "Guidelines for verification of greenhouse gas emissions in Hubei" were formulated to provide strong institutional support for the market operation. Third, Hubei successively issued "Detailed rules for carbon emission right offset of Hubei in 2015", "Implementation rules of allowance custody business of China Hubei Emission Exchange", "Measures for the administration of revenue and expenditure of transferring fees for carbon emission rights", and "Measures for the management of carbon emission allowance release and repurchase" to carry out business innovation.



Figure 5: Series of Documents on Hubei ETS

2 | Industry selection

Combined with the characteristics of Hubei's industrial structure, considering the administrative cost and the representation of the industry, the principle of "focusing on the large and letting go of the small" is followed in the selection of the covered enterprises. The first batch of 138 industrial enterprises covered by Hubei ETS were enterprises with a comprehensive energy consumption of 60,000 tons of standard coal or above in any year from 2009 to 2011, which accounted for 35% of the province's total carbon dioxide emissions, covering 12 industries included electric power, iron and steel, non-ferrous metals and other metal products, medicine, automobile and other equipment manufacturing, chemical fiber, petrochemical, cement, food and beverage, glass and other building materials, chemical and paper. In 2015, 29 new enterprises were added and the total covered industries rise to 15. After 2017, the threshold for coverage in Hubei ETS was lowered to 10,000 tons of standard coal, in line with the national ETS, covering 16 industrial sectors and 373 industrial enterprises.

3 | Carbon allowance allocation

Hubei ETS is a mix system, that is, about two thirds sectors covered by Hubei ETS adopt grandfather method (mass-based system) and one thirds adopt tradeable performance standard (rate-based).

In terms of allowance allocation, Hubei ETS has the following five characteristics:

(1) Allowance allocation is moderately tight. In 2014, by multiplying the average emissions from 2009 to 2011 by 0.9192, Hubei ETS had the tightest allowance allocation among the seven ETS pilots. After 2015, the adjustment coefficient was set for each industry, and the benchmarking method was expanded from the power industry to the co-generation of heat and power, cement and steel industries. The historical intensity method was also introduced.

(2) Allocate once a year. It is convenient for the competent department to set reasonable annual emission reduction targets in time according to the economic development and formulate the total emission in line with the actual development of the year.

(3) Cancel the allowance after expiration. To prevent allowances from accumulating across years and affecting emission reduction targets as well as the balance of demand & supply, the allowance allocated in the current year must be canceled in the end of the current year. Banking is allowed, but only for allowances that were traded at least once.

(4) Double "20" to control market risk. At the early stage of the pilot, due to the weakness of the basic data, according to the principle of correspondence between rights and responsibilities, the compliance burden was locked within 200,000 tons or 20% of the initial allowances allocated when covered enterprises actual carbon emission are more than their initial allowances allocated, vice versa. On the one hand, it avoids the adverse impact of the remaining allowances on the market by firms holding large amounts of allowances. On the other hand, it makes the cost of compliance predictable and controllable, and eliminates the concern of enterprises about compliance cost.

(5) Set the annual market adjustment coefficient. When allocating the allowance of the current year, the imbalance between supply and demand of the allowances of the previous year shall be balanced through the market adjustment coefficient.

4 | Trading mechanism

(1) Market regulation and control mechanism. First, 8% of the total allowance is reserved for the competent government departments to regulate the market.

Second, the trading rules focus on risk prevention and control. The market risks are resolved through price limit and daily bargaining ranges.

(2) Discover the price by auction. The government set aside part of the allowances for market regulation. The price of 2 million tons was auctioned for the first time before the market opened in 2014. It was found that the formed carbon price effectively guided the operation of the market.

(3) Open and Enrich the market. On the one hand, Hubei ETS is open to all kinds of investors with low threshold, and the main participants include domestic and foreign institute and individual investors. At the same time, Hubei ETS provides two types of transaction mode, "negotiated bargain transfer" and "fixed price transfer" to meet the needs of different market subjects.

5 | MRV system

Establish an institutionalized management system for verification and standardize the management of verification submission. *"Interim measures for the management and transactions of ETS pilot in Hubei"* clarifies the rights and obligations of covered enterprises and verification institutions in the verification of carbon emission. Covered enterprises are required to submit carbon emission monitoring plans and carbon emission self-test reports in accordance with regulations. The third-party verification organizations shall independently, objectively and impartially verify the annual carbon emission report of the covered enterprise, and form the enterprise carbon emission verification report as the basis for allowance management.

6 | Offset mechanism

The Chinese Certified Emission Reduction (CCER) pre-issuance mechanism was first created. The competent department of the Hubei ETS issued offset mechanism management measures to innovate the pre-issuance offset of CCER. Covered enterprises can use the record items not yet issued by the National Development and Reform Commission for offset in advance. We think CCER should be encouraged to develop and increase its offset proportion gradually.

(1) In 2014, the conditions for offsetting emission reductions were clarified. China's certified voluntary emission reductions for offsetting in Hubei ETS shall meet the following conditions at the same time:

- 100% of the recorded emission reductions can be used for offsetting. The unrecorded emission reductions shall be used for offsetting by a proportion not higher than 60% of the emission reductions within the validity period of the project.
- CCER needs to come from provinces and municipalities outside the boundaries of Hubei's organizations that are included in the management

of carbon emission allowances, or that have signed ETS agreements with Hubei. The annual emission reduction used for offsetting shall be no more than 50,000 tons.

- Not generated by large and medium sized hydropower projects.
- Register in the Hubei registration system.

(2) In 2015, the conditions for offsetting emission reductions were clarified. China's certified voluntary emission reductions for offsetting in Hubei ETS shall meet the following conditions at the same time:

- Within the administrative region of Hubei, it is generated outside the boundaries of enterprises that are included in carbon emission allowances management.
- Emission reductions from rural biogas and forestry projects recorded by the National Development and Reform Commission. Among them, the project area is a contiguous impoverished area of the province. The crediting period of the project is from January 1, 2015 to December 31, 2015.
- The offset proportion shall not exceed 10% of the initial annual carbon emission allowance of enterprises included in carbon emission allowance management. One ton of CCER is equivalent to one ton of carbon emission allowance.
- Register in the Hubei carbon emission trading registration system.

7 | Compliance management

“Interim measures for the management and transactions of ETS pilot in Hubei” stipulates credit records, supervision by public opinion, project approval, allowance deduction, economic punishment and so on. Covered enterprises that fail to comply face the following penalties:

(1) In accordance with the average market price of carbon emission allowances for the current year, a fine of more than one time and less than three times shall be imposed on the difference in compliance allowances, and double deduction will be made in the allowance allocation of the next year.

(2) The defaulting unit will be listed as integrity, credit blacklist or bad record.

(3) The list of defaulting enterprises will be announced to the society through the government website and news media.

(4) If the defaulting enterprise is a state-owned enterprise, its default will be notified to the relevant state-owned assets supervisory department and included in the performance evaluation system of state-owned enterprises.

(5) The development and reform departments at all levels in Hubei shall not accept the relevant national and provincial energy conservation and emission reduction projects declared by the defaulting units.

The comprehensive and strict compliance constraint mechanism has played a positive role in urging enterprises to complete their emission control targets and achieve 100% compliance every year.

8 | Platform construction

Three electronic platforms including carbon emission trading system, registration system and MRV system are built to provide management support for regulated enterprises, institute and individual investors in Hubei.

(1) Registration system. Designed according to the relevant technical specifications and standards of ETS allowance management, the system covers the functions of allowance issuance, cross system transfer, compliance, cancellation, CCER management etc. The framework of the registration system is reasonable, the business coverage is comprehensive, the function is carefully considered, the practicability is strong, safe and reliable, and the operation is stable, which provides support for the management of allowance and business innovation of the competent department of Hubei ETS.

(2) Trading system. The design of the system focuses on standardization, efficiency and security. The carbon trading platform is fully functional, easy to operate, safe, reliable, open and transparent, providing services for carbon trading participants in Hubei. Besides, by developing Android and IOS mobile clients, it makes the operation more convenient.

(3) Emission reporting system. Through the construction of a standardized and reliable emission reporting system, regulated enterprises are required to submit monitoring reports regularly to provide data support for verification.

B | Effectiveness of Hubei ETS

1 | The trading market operates effectively, prices keep smooth and steady, and the market incentive mechanism has formed basically

At present, the scale, continuity, amount of social capital introduced, and the participation of enterprises in Hubei ETS rank top 1 in China. As of April 30, 2021, the

cumulative turnover of the secondary market in Hubei was 347 million tons, with a turnover of 8.147 billion yuan, accounting for 51.01% and 56.15% of China respectively.



Figure 6: Trading Volume and Price of Hubei ETS

The effective trading days in the market accounted for 100%, transaction rate of enterprises was 100%, and compliance rate of enterprises was 100%. The carbon price was relatively stable, basically keeping between 15 and 40 yuan, while the market has neither interruption nor complaints. By giving a certain price to carbon emissions, in the short term, enterprises with high emission reduction costs can achieve compliance at low cost through market transactions and gain time for transformation and upgrading; while enterprises with low emission reduction costs can gain additional revenue through the carbon market. In the long term, a stable carbon price is expected to provide profit expectations for enterprises to invest in carbon emission reduction technologies, which will help promote the research and development of energy-saving technologies.

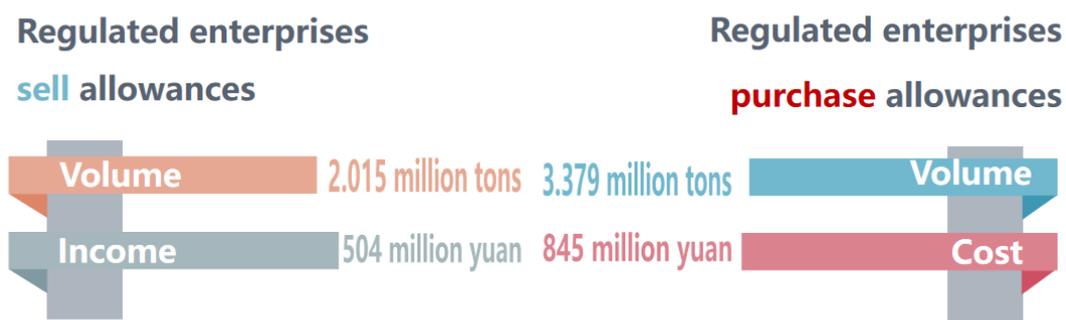


Figure 7: Volume and Income of the Allowances Sell and Purchase by Regulated Enterprises

According to the relevant statistics, regulated enterprises sold 2.015 million tons allowances and made 504 million yuan in profit through the ETS during this period. At the same time, they paid a cumulatively cost of 845 million yuan for the purchase of 3.379 million tons allowances.

2 | Under scientific allocation of allowances, enterprises have achieved remarkable results in reducing emissions, the ETS plays a positive role in reducing emissions

Hubei has tightened the allocation of allowances by tightening benchmark values, industry emission control coefficients, market adjustment factors, and cancellation of free allowances due to expiration, which effectively force enterprises to reduce emissions. In 2019, 73% of the 111 enterprises which used the carbon intensity method to allocate allowance have decreased their emissions intensity, and 60% of the 228 enterprises which used the historical emission method to allocate allowance have decreased their emissions.

Based on provincial panel data from 2008-2016 and using a difference-in-difference approach, we find that the Hubei pilot carbon market policy led to a 19.8% and 20% decrease in total carbon emissions and carbon intensity (carbon emissions per unit of GDP) in Hubei, respectively. Based on the data of Chinese listed enterprises from 2003-2016, using a difference-in-difference approach, we find that the pilot carbon market policy in Hubei led to a significant increase of 8.9% in the export green-sophistication of listed enterprises in Hubei.

As can be seen from Figure 7, from 2014 to 2019, the growth rate of the added value of the secondary industry in Hubei (10.1%, 8.9%, 7.8%, 7.1%, 6.8%, 8.0%) was higher than the national average (7.3%, 6.0%, 6.1%, 6.1%, 5.8%, 5.7%). It has shown a good momentum of high-quality economic development, while saving energy and reducing carbon emissions.

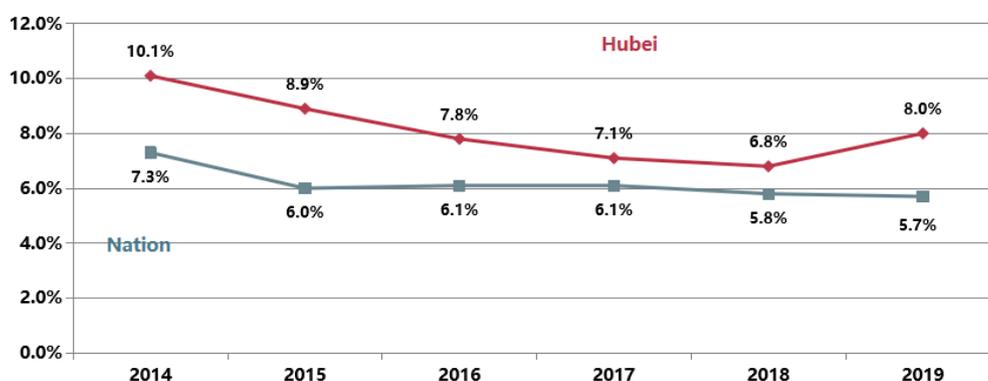


Figure 8: Growth Rate of the Added Value of the Secondary Industry in Hubei and Nation

3 | The offset mechanism realizes precise poverty alleviation and provides an important policy tool for carbon neutrality

With the offset mechanism, Hubei ETS gave priority to supporting the offset of agroforestry projects. It also explored the ecological compensation mechanism of “industry compensates for agriculture, urban compensates for rural areas, and carbon emission compensates for carbon sink”, which achieved environmental and economic

benefits. By making full use of its advantages, Hubei has developed 128 agroforestry projects, including 55 rural biogas projects, ranking first in China, with an average annual emission reduction of about 2.14 million tons. In addition, 8 forest carbon sink projects including China's first bamboo carbon sink project have also been developed. From 2014 to 2019, Hubei CCER offset 3.52 million tons and generated a total income of about 67.94 million yuan.



Figure 9: Offset Projects in Hubei

The agroforestry projects in impoverished areas offset 2.17 million tons and generated income of 50 million yuan, accounting for 73% of the total income.

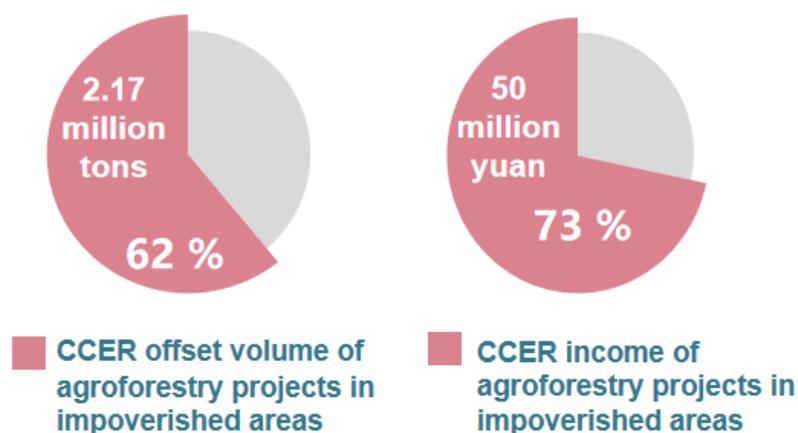


Figure 10: 2014-2019 Offset Situation of Agroforestry Projects in Impoverished Areas

The regulated enterprises offset the greenhouse gas emissions in the industrial production process through the purchase of voluntary emission reductions, which provide a good solution and policy tool for achieving carbon neutrality.

4 | With various carbon financial innovations, Hubei ETS broadens the financing channels of enterprises, reduces their financing costs, and lays the foundation for Hubei to carry out climate investment and financing pilot projects

Hubei ETS has actively carried out various carbon financial innovations and keep several first records in China. The first carbon emission rights pledge loan business in China was carried out, resulting in a total of RMB 1.54 billion carbon emission rights pledge loan, and the capital needs of enterprises were solved; The country's first carbon fund was established with an amount of 30 million RMB to help promote market liquidity and reduce market price risk; The first carbon allowance escrow business in China was facilitated, resulting in a total of 5.92 million tons of carbon assets escrowed, which realized profitable transactions; The first domestic carbon spot forward trading product was developed, with a total trading volume of 260 million tons and a total transaction amount of 6.19 billion RMB; National CCER carbon crowdfunding project - "Hong'an County Rural Household Biogas CCER Development Project" was innovated to solve the project development fund of 200,000 RMB. The first carbon insurance business in the country was launched.



Figure 11: Carbon Financial Projects in Hubei

Hubei ETS has also signed carbon finance credits with six banks to support the development of green and low-carbon projects and technology applications, the scale reached more than 120 billion yuan. Carbon finance innovation helps enterprises revitalize their carbon assets, broadens their financing channels, and reduces their financing costs. A series of innovative activities have enhanced the enthusiasm of enterprises to comply and reduced their cost of compliance.

5 | Explore the Carbon Inclusion voluntary trading model, and use the market mechanism to guide low-carbon consumption and life

When various events are held, carbon dioxide emissions will be generated due to venue construction, transportation, etc. Hubei ETS can help create low or zero carbon events by collecting carbon emission reductions generated by individual users and donating them to event organizers. Since 2019, Hubei ETS has cooperated with the Organizing Committee of the Military World Games and Winter Olympics to launch the "Low-Carbon Military World Games" and "Low-Carbon Winter Olympics" WeChat mini-programs. Garbage sorting and recycling, "clear your plate" campaign, other low-carbon life and green consumption data are collected and converted into carbon emission reductions in WeChat mini-program. Individuals can donate emission

reductions to the Military World Games and Winter Olympics to achieve zero carbon event.



Figure 12: Related Activities in Low-Carbon Military World Games and Winter Olympics

Taking the Military World Games as an example, the total emission reduction of more than 100 tons generated by 75,447 users of the "Low-Carbon Military World Games" application in 121 days was used to neutralize the carbon emissions from food, housing and transportation of athletes during the games. Besides, 93.8 thousand tons of forestry carbon sinks generated by the second phase of the carbon sink afforestation project in Tongshan, Hubei from 2017 to 2023 were used to neutralize carbon emissions from the construction of the Military World Games venues, waste disposal and other activities. This is the world's first carbon neutral model for large-scale sports event, and has been highly recognized by the public and news media.

6 | By constructing a capacity building service system, Hubei has carried out capacity building to enhance the influence of the ETS

With the National Carbon Trading Capacity Building Training Center, a professional, standardized and large-scale service system has been established, including 1 physical training center, 1 online learning center and N industrial training demonstration bases. The training covers all provinces across China, a total of more than 50 sessions were organized, reaching more than 10,000 person-times. Foreign cooperation channels were established, it undertook ASEAN capacity building training on climate change for two consecutive years in 2016 and 2017. In 2019, it undertook training on greenhouse gas emission reduction and energy transformation. More than 300 people from various national environmental protection departments and research institutions participated in the training. In 2020, training on the registration system and the simulated trading of allowances in the power generation industry was carried out to provide support for the construction of the national ETS. In 2021, with the proposal of the carbon peak and carbon neutral goal, 18 new occupations were promulgated, and the carbon emission manager training and the carbon peak and carbon neutrality

special training were carried out to strengthen the construction of talent team in carbon emission and carbon market related fields.

C | Summary of experience of Hubei ETS construction and development

1 | Strengthen organizational leadership and improve working mechanism

The provincial party committee and the provincial government attach great importance to the construction of ETS, and have held several meetings to study and deploy related major issues. The provincial government has established the Provincial Leading Group for Climate Change, which is responsible for coordinating and deploying the work of ETS. The competent department has established a multi-departmental and interdisciplinary expert committee for carbon trading to provide decision-making consultation and technical support for the development of Hubei ETS. The working mechanism of government-led, expert consultation and multi-department participation has been gradually formed. At the same time, through increasing capital investment, the provincial government invests 15 million yuan every year, focusing on special research on carbon trading, platform, system and capacity building as well as corporate carbon emissions verification.

2 | Improve the policy system and build system platforms

A series of regulations and documents have been formulated and issued, such as *“Implementation plan for the pilot project of carbon emission trading in Hubei”*, *“Interim measures for the management and transactions of ETS pilot in Hubei”*, *“Allowance allocation scheme for ETS pilot in Hubei”*, *“Guidelines for verification of greenhouse gas emissions in Hubei (for trial implementation)”*. These created a system of regulations and policies to support all aspects of carbon trading, from top-level design, carbon emissions data verification, allowance issuance and market trading, thus forming an up-and-down supporting system. By developing a standardized and stable registration system, trading system and greenhouse gas emission reporting system platform, it has accumulated rich experience in system development, operation and maintenance management and risk management. The completion of the three platforms have provided a solid platform to support carbon trading.

3 | Adhere to taking energy saving and carbon reduction as the primary task of ETS construction

Reducing emissions through market mechanisms is the original intention of building the ETS. Over the past few years, adhere to the principle of active and prudent with moderate pressure, Hubei adopt a scientific and rational determination of the annual initial allowance and adjustment mechanism to allocate enterprise allowances.

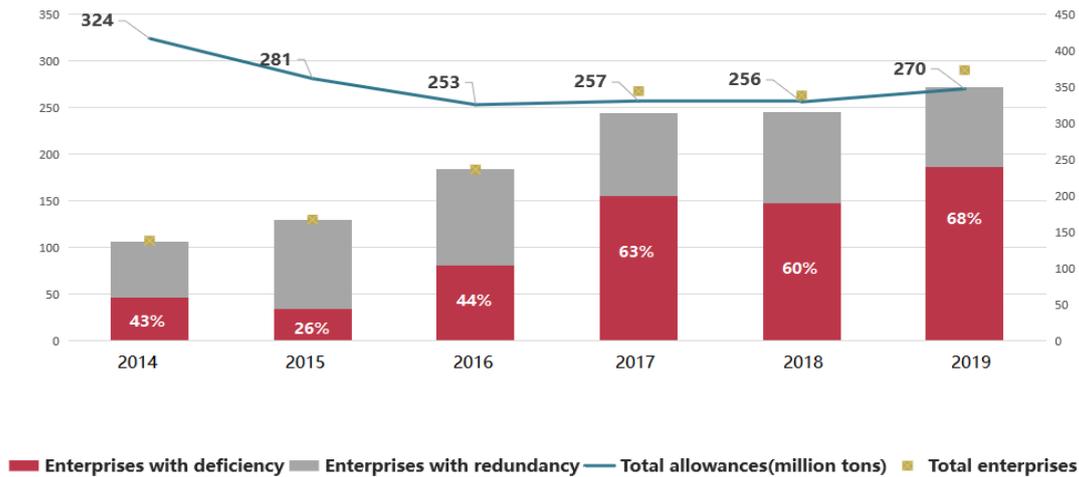


Figure 13: Total carbon allowances, Deficiency and Redundancy

As can be seen from Figure 12, from 2014 to 2019, the number of regulated enterprises in Hubei was 138, 167, 236, 344, 338 and 373, and the total carbon allowance was 324, 281, 253, 257, 256 and 270 million tons respectively. The number of enterprises increased while the total amount of allowances has decreased. Meanwhile, the proportion of enterprises with allowances deficiency increased from 42% in 2014 to 68% in 2019, an increase of more than 60%, which can force enterprises to reduce emissions. Overall, from 2015 to 2019, a cumulative volume of 17.6 million tons emissions were reduced, and 14 among 16 industries achieved emissions reduction

4 | Aim at emission reduction targets and distribute them scientifically and rationally

System design is the key to carbon trading. Hubei has embodied four emphasis in the design of the allowance allocation system. Focus on the combination of carbon intensity reduction goals and development space, and set the CAP according to the province's carbon intensity reduction goals and expected GDP growth. Meanwhile, pay attention to fully consider the affordability of enterprises, and set an upper limit of 20% of the initial allowance or 200,000 tons for the enterprise's allowance gap to ensure moderate pressure and reduce work resistance. Focus on enhancing market liquidity and continuity, the allowances are issued for free but untraded allowances are canceled when expire, so the enterprise can spread the transaction in usual. Pay attention to the gradual optimization of the policy system, the allowance is issued once a year, and the allocation plan is optimized and adjusted every year to make allocation more scientific

5 | Carry out various innovations and expand market functions

Actively carry out carbon financial innovation, and successively launch carbon asset pledge loans, carbon funds, carbon asset custody, carbon crowdfunding, allowance spot forward trading, carbon insurance and other carbon financial services to help

enterprises revitalize carbon assets, expand corporate financing channels, and reduce financing costs. Help enterprises to expand financing channels, and form a pattern of ETS development supports carbon financial innovation, and carbon financial innovation promotes ETS development. In terms of offset mechanism, the ecological compensation mechanism of government guidance, institutional participation, and farmers' benefit has been explored. Innovate the ecological poverty alleviation mode. Give priority to supporting the transaction of CCER of agricultural and forestry projects and compliance offset. Increase the income of agricultural and forestry owners. Optimize the rural energy structure and achieve ecological and environmental benefits and social benefits. In conjunction with the Provincial Forestry Department, Agriculture Department, Poverty Alleviation Office and other departments, it has promoted the development of forestry and rural household biogas projects. The number of projects developed has reached 128, ranking first in China.

6 | Strengthen risk prevention and ensure smooth compliance of ETS

Attaching great importance to the compliance work, Hubei has introduced extraordinary measures such as the allowance release and repurchase system, and adjusting the range of daily bargaining price fluctuations to prevent the sharp rise and fall of carbon prices to ensure the stability of carbon prices. By organizing expert seminars, arranging deployment in a unified manner, analyzing the overall supply and demand of the market, paying attention to abnormal enterprises, and formulating emergency plans, Hubei has realized fully prepare in advance. Coordinate in a timely manner to guide enterprises with large gaps to buy allowances at lower prices and avoid high compliance costs. Through the monitoring of deposits and withdrawals and allowances transfer to pay attention to large-amount funds and large-scale transactions, avoid manipulating market prices, and take measures such as interviews and warnings for entities that disrupt the market order. The last is to summarize and sort out afterwards. After compliance, convene the supporting institutions to summarize the problems and experience of compliance, and make full preparations for the allowance allocation, verification and compliance for next year.

Among the seven ETS pilots in China, Hubei ETS is the most representative since the economic level and industrial structure of Hubei are the closest to the national average. Hubei has achieved a good balance between emission reduction and economic growth, the carbon emissions of regulated enterprises account for 45% of the province's total. While reducing emissions, Hubei's economy has maintained a medium-to-high speed growth. The effectiveness of the pilot project in Hubei fully proves that it is practical and feasible to promote the ETS in China, and the ETS is effective in promoting the construction of ecological civilization and carbon neutrality.

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AUTHOR CONTRIBUTION

Zhang Xiliang and Yu Runxin wrote issues about China's national ETS, that is, chapter 1 to chapter 5. Qi Shaozhou and Yang Guangxing wrote case study of Hubei ETS, that is, chapter 6.