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From Local Carbon Emissions Pilots to the National Carbon Emissions Trading Scheme in China

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Chunyan Dai

Michael G. Pollitt

Abstract

This paper discusses China's move from local carbon markets (CL-ETS) to a national carbon market (CN-ETS). We explore the challenge of expanding the CN-ETS to include sectors already covered in some of the CL-ETSs. We do this in three ways. First, through a systematic review of relevant policy documents and market data, the study analyzes the background and development process of the CN-ETS. Second, in-depth interviews with 22 industry experts are conducted to gather insights from various stakeholders regarding industry expansion and data quality issues, forming a multidimensional understanding of the market's status. Finally, quantitative analysis methods are used to statistically analyze the collected data and explore the impact of different factors on the development of the CN-ETS. We find that the CN-ETS currently faces challenges in industry expansion, such as insufficient data quality and complex accounting, which directly affect the market's effective operation. Experts differ in their views on the possible speed of expansion. However, we identify 2034 as a crucial date for the achievement of a comprehensive strengthening of the CN-ETS, in the light of the implementation of the European Union's Carbon Border Adjustment Mechanism (CBAM).

Keywords Emission Trading System (ETS), Carbon Border Adjustment Mechanism (CBAM), European Union Emissions Trading System (EU ETS), China's national Emissions Trading System (CN-ETS), China's local Emissions Trading System (CL-ETS)

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Chunyan Dai[1,2,3]
and
Michael G. Pollitt[3]

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1.Chongqing Engineering Technology Research Center for Information Management in Development, Chongqing, China
2.Research Center for Upper Reaches of the Yangtse River, Chongqing Technology and Business University, Chongqing, China
3. Energy Policy Research Group, Cambridge Judge Business School, University of Cambridge, United Kingdom

1 Introduction

Climate change and environmental concerns arising from carbon emissions have garnered global government attention. Emissions Trading System (ETS) serve as a policy tool to mitigate greenhouse gas emissions by facilitating emission reduction while minimizing associated costs through market mechanisms (Spaargaren et al., 2013). Numerous countries and regions worldwide have initiated their carbon emissions trading systems (ETS) (ICAP, 2023). As of December 31, 2022, 34 carbon ETSs were operational globally (WB, 2023). In its pursuit of carbon emissions peaking and carbon neutrality goals, China, has progressively implemented an ETS to combat climate change, alongside traditional policy measures like adjusting its energy mix and upgrading industrial structures.

The development and refinement of a carbon market is a protracted process. The European Emissions Trading System (EU-ETS), recognized as the world's most successful, has undergone 18+ years of evolution since its inception in 2005, marked by continuous exploration and improvement. Likewise, the establishment of China's national ETS (CN-ETS) has been a gradual process (Liu et al., 2022). Commencing with the 2011 *"Notice on Carrying out Pilot Projects for Carbon Emissions Trading"* from the National Development and Reform Commission (NDRC), seven pilot carbon markets were launched in Beijing, Tianjin, Shanghai, Guangdong, Shenzhen, Hubei, and Chongqing from June 2013 onwards (NDRC, 2011). Fujian also joined the pilot carbon emissions trading initiative in August 2016 (ICAP, 2016). These local pilot carbon trading systems (CL-ETSs) significantly contributed to improving carbon emission quota allocation and trading system construction, highlighting the importance of greenhouse gas emission control and path exploration in pilot provinces and cities. After a decade of preparation, CN-ETS officially commenced on July 16, 2021, with the first transaction at 52.78 CNY (€6.8), involving 160,000 tonnes of emissions valued at 7.9 million yuan (MEE, 2022). Initially, only the power sector was included in the CN-ETS, accounting for 4.5 billion tonnes of CO_2 (around 9% of global emissions) permits and establishing it as the world's largest ETS market by volume (MEE, 2022). This launch is a pivotal step in the fight against climate change.

In March 2021, China's Ministry of Ecology and Environment (MEE) drafted the "*Interim Regulations on the Administration of Carbon Emissions Trading*," stipulating that "no new CL-ETS will be established post-implementation of these regulations. Existing CL-ETS markets shall be gradually incorporated into the CN-ETS. Major industries, including building materials, steel, non-ferrous metals, papermaking, and aviation, are planned to be integrated into the CN-ETS, with specific steps and measures to be formulated by the ecological environment department of the State Council."（MEE,2021). In essence, CL-ETS and CN-ETS will coexist but not overlap, requiring units to withdraw from any CL-ETS upon inclusion in the CN-ETS. Additionally, provincial authorities can expand CL-ETS to encompass entities below national thresholds and those in non-covered industries to support provincial carbon intensity targets. However, delays in including high-

emitting industries in the CN-ETS have been observed due to carbon emission data quality, and the duration of CL-ETS remains uncertain, contingent on the state of industries sectors entering the CN-ETS.

With the formal implementation of the CBAM, China's energy-intensive industries face unprecedented pressure on their exports to jurisdictions adopting CBAMs. To address this challenge, expanding sectors into the carbon market and promoting the green transformation of industries and economic development have become imperative choices. Therefore, it is imperative to meticulously examine the primary challenges such as data quality issues that loom over the expansion of sectors, exploring how major industries should position themselves as they gradually exit China's local Emissions Trading System (CL-ETS) and transition into the CN-ETS, as well as how the CN-ETS should be constructed. This analysis seeks to offer a thorough and in-depth discussion of the cost-effective transition process in expanding sectors from CL-ETS to CN-ETS, minimizing additional expenses associated with the integration of the CL-ETS into the CN-ETS framework, promoting the healthy and efficient operation of the carbon trading market.

This study serves as a consolidation of existing research and practical foundations pertaining to the expansion of sectors within the CN-ETS. It delves into critical aspects such as the pace and sequencing for extending CN-ETS coverage beyond the power sector, addresses the challenges related to data quality that arise during the expansion of sectoral coverage within the CN-ETS, identifies the essential components of a robust Measurement, Reporting, and Verification (MRV) system for environmental regulation enhancements, and explores the complementary role played by CL-ETS in fostering cost-effective development within the CN-ETS landscape. Leveraging insights drawn from international experiences, including the EU-ETS I (the existing Emissions Trading System), EU-ETS II (the forthcoming Emissions Trading System encompassing heating and transport sectors in the EU), and the German Emissions Trading System, this research endeavors to provide valuable perspectives on sectoral expansion within the CN-ETS.

This paper delineates the research methodologies employed, the resulting findings, and the central recommendations. The overarching objective is to facilitate the expansion of the CN-ETS and offer comprehensive guidance for the formulation of a precise timetable and a strategic roadmap for the seamless transition from CL-ETS to CN-ETS. The paper's structural framework as following. Section 2 serves as the introduction, offering a comprehensive overview of the research perspectives and methodologies employed in this study. Section 3 presents empirical insights gleaned from a rigorous examination of pertinent literature, meticulous document analysis, and insightful semi-structured interviews. Section 4 presents recommendations aimed at establishing a precise timetable and a strategically sound approach for the seamless transition from CL-ETS to CN-ETS, seeking to provide valuable guidance for policymakers and stakeholders involved in this crucial transition. Finally, section 5 encapsulates the conclusions derived from the analysis conducted in the study, offering insights and implications for future endeavors in the realm of CN-ETS.

2 Materials and methods

This study adopts a triangulation approach in conjunction with an inductive research strategy, drawing inspiration from the works of Burns et al. (1989), Thomas et al. (2003) and Jebreen et al. (2012). The concept of "triangulation" originally finds its roots in geometry, wherein it involves constructing a triangle from a known point to an unknown point to determine the latter's precise location (Donald et al., 1984).

In the realm of social sciences, Creswell and Miller (2000) define triangulation as a validity-enhancing procedure in which researchers seek convergence actively among various and distinct sources of information to develop coherent themes or categories within a study. Triangulation refers to the deliberate utilization of multiple methods or data sources to explore the same theme or phenomenon. This includes methods such as interviews and quantitative surveys, all aimed at bolstering data validity, which pertains to the data's capacity to effectively expound upon research outcomes. Furthermore, it serves the vital purpose of promoting research neutrality and objectivity (Olsen et al., 2004; Hussein et al., 2009).

In the domain of public policy and governance research, this methodological approach proves particularly pertinent (Bekhet & Zauszniewski,2012). It enables the creation of a comprehensive portrayal of current issues and processes, thus facilitating multidimensional comparative analysis of the resultant data. Such multifaceted analysis is indispensable for achieving an in-depth understanding of complex phenomena (Tzagkarakis & Kritas, 2023). Essentially, triangulation entails the harmonious integration of two or more methodological approaches, theoretical perspectives, data sources, investigators, and analytical methods, all brought to bear on the examination of the same phenomenon (Triangulation, 2014).

Triangulation involves four sequential steps. The first phase comprises a thorough literature review and secondary quantitative research. Subsequently, progresses into primary quantitative research, via well-designed questionnaires. The third step revolves around primary qualitative research, executed through a combination of semi-structured interviews and narrative interviews. The final stage involves analyzing newly acquired primary data while conducting a comparative assessment against existing literature and secondary quantitative data (Tzagkarakis & Kritas, 2023). The overarching goal is to correlate primary qualitative and quantitative data, resulting in well-founded and nuanced conclusions (Heale & Forbes,2013). In this study, a rigorous and comprehensive four-step triangulation approach is implemented. This approach draws upon records obtained from semi-structured expert interviews (Smith et al., 1995) and an array of documentary sources, including academic literature, official government records, and media reports. The incorporation of such diverse and reputable sources not only bolsters the study's data validity but also increases the reliability of the findings, substantially enhancing the overall credibility of the research.

The initial phase involved a literature review combined with research on the expansion of the sectors in CL-ETS and CN-ETS. Academic literature is sourced from Google Scholar, Web of Science, and CNKI, using keywords such as ETS, carbon market, China, pilots and EU. Official government records encompass key government policies, five-year plans, regulations, and documents issued by the State Council (SC) and government agencies responsible for ETS development in China. Pre-2018, these agencies included the National Development Reform Commission (NDRC) and Local Development and Reform Commissions (LDRCs), while post-2018, they consisted of the Ministry of Ecology and Environment (MEE) and local Bureaus of Ecology and Environment (LBEEs). Media reports and research reports were gathered from recent publications and reports on ETSs by professional and official media/platforms from China, the United Kingdom (UK), the EU, and other countries and regions.

Then the semi-structured interviews were designed. In the design of the interviews, four open-ended questions were formulated based on a comprehensive review of the literature on the research theme and observations of the real-world context.

Question 1: How quickly and in what order will carbon market coverage be extended from the power sector to other sectors？ Is it likely that full coverage of key emission industries such as petrochemicals, nonferrous metals, chemicals, paper, building materials, steel, and aviation will be achieved during the "14th Five-Year Plan "?

Question 2: What improvements need to be made to environmental regulation if China is to have a mature carbon market? Are there any examples of good local and provincial practice in environmental monitoring?

Question 3: Under the background of building a unified national carbon market, how do local and national carbon markets develop cost-optimally together?

Question 4: What are the most important lessons for China from international experience with carbon markets? What international experience of carbon markets would you most like to know more about in the construction of CN-ETS especially in the move from CP-ETSs to CN-ETS?

Question 1 aimed to explore the timeline for the sector's expansion, while Questions 2 to 4 sought to examine issues related to sectoral expansion from three distinct perspectives: the national level, the local level, and the individual level within a global context.

All interviewed experts had direct involvement in either the CN-ETS or the CL-ETS or possessed extensive experience in ETS research, including familiarity with international ETSs such as EU-ETS, UK-ETS, the Regional Greenhouse Gas Initiative (RGGI) in the US, the New Zealand ETS (NZ-ETS), and Tokyo-CAT, in addition to CN-ETS and CL-ETS. The experts for the semi-structured interviews divided into two categories. The first category comprised practitioners, including relevant officials responsible for CN-ETS at China's National Development and Reform Commission (NDRC), officials responsible for CL-ETS from the Local Development and Reform Commission (LDRC) or the Local Ecology and Environment Bureau (LBEE) in the eight carbon trading pilot areas, and officials in charge of national or local ETS trading centers (exchanges). The second category consisted of academic experts with a minimum of ten years' experience in carbon trading market research and familiarity with at least one international ETS or CN-ETS or one CL-ETS, including the eight pilot ETSs in Beijing, Shanghai, Tianjin, Hubei, Chongqing, Guangdong, Shenzhen, and Fujian. The sampling of interviewees was carried out through a combination of judgmental sampling and referral sampling methods, ensuring comprehensive coverage across various ETS levels (international, national, and different pilot areas) was achieved (Taherdoost, 2016). Judgmental sampling involved the deliberate selection of specific individuals or events to obtain vital information not obtainable through alternative choices (Maxwell, 1996).

The semi-structured interviews were conducted in face to face, using online video conferencing tools such as Tencent Meeting, Zoom, or WeChat videophone. Notably, most interviews were conducted in Chinese and later translated into English, while some interviews were conducted in English, despite it not being the first language of either the interviewer or interviewee. Thus, some nuances in language may have been lost during the interview or translation of transcripts. The interviews took place from mid-March 2023 to the end of July 2023, with contact established based on factors including the relationship between interviewees and interview partners, formality levels, and the position of interview partners. The research team employed email templates to contact and invite experts, with translations into local languages when deemed necessary. These templates included information about the research project, the interviewer, and details regarding the interview date, location, and duration. The mode of initial contact (email or telephone) and subsequent follow-up methods were determined by the authors. Prior to their interviews, experts were asked for permission to record the session for accuracy. Anonymity was ensured by guaranteeing that personal data would not be disclosed to third parties or made public. At the interview's conclusion, experts were given an opportunity to add comments and insights they deemed relevant to the topic and interview, as well as to suggest additional experts for the study. The interviews were recorded and transcribed verbatim, with text transcripts stored on the first author's computer. Identifying labels were removed from file names. In total, 22 semi-structured interviews were conducted (refer to Appendix Table 1 for an overview).

In the final phase of the research, the findings from different expert interviews were triangulated using comprehensive document research and analyzed through a combination of narrative and critical discourse analysis. Additionally, international ETS practices were compared. The triangulation process, which involved the synthesis of various information sources, facilitated the generation of constructive suggestions for government decision-makers through an inductive approach.

3. Results and Discussion

For each of the four forthcoming subsections we distill the answers we got to the questions we asked our expert interviewees.

3.1 Timetable for carbon market coverage to be extended from the power sector to other sectors in CN-ETS

Since China's decision to establish the CN-ETS, there has been a planned expansion of the sectors included in the CL-ETS and then to CN-ETS (NDRC, 2011). Various CL-ETSs have launched useful explorations in industry coverage at their beginning. Due to the different economic structures of the pilot provinces, the scope of industries included in the various CL-ETSs is different (Lin et al.,2017; Lin et al.,2020). For example, the tertiary industry in Shenzhen, Beijing, Shanghai and other places dominates, so the transportation industry, service industry, and public management departments are included (Jiang et al., 2016; Zhang et al., 2021). At the same time, there are also differences in the emission control thresholds of each CL-ETS. For example, there are a few industrial enterprises in Shenzhen and Beijing with limited scale, and the industrial emission control thresholds are lower than those of other CL-ETS (Zhang et al.,2014). The commonality of the coverage of each CL-ETS is that industries with higher emissions and greater room for emission reductions are included, such as power production (until 2021) and energy intensive manufacturing (Zhang et al.,2014; Lin et al.2017; Deng et al., 2018).

In 2016, the National Development and Reform Commission (NDRC) published Document No. 57, outlining the first phase of the CN-ETS, which was set to encompass petrochemicals, chemicals, building materials, steel, non-ferrous metals, papermaking, electric power, aviation, and other key emission industries (NDRC, 2016a). On December 19, 2017, NDRC proposed the step-by-step construction of the CN-ETS carbon market, starting with the power generation industry (including cogeneration of heat) and gradually expanding the scope of participating industries and trading varieties of financial contracts, with the aim of steadily improving the carbon market in China (NDRC, 2017).

In July 2021, the CN-ETS officially commenced trading, initially covering the power generation industry. As per the construction plan, the CN-ETS is expected to progressively include 13 key sub-sectors within the seven key emission industrial sectors, including petrochemicals, iron and steel, non-ferrous metals, papermaking, electric power, chemical industry and building materials, during the "14th Five-Year Plan" period from 2021 to 2025 (NDRC, 2017). However, it appears that the expansion of sectors is taking longer than anticipated. Initially, there was optimism that two to three industries would be included in 2022. Nevertheless, on March 15, 2022, the Ministry of Ecology and Environment (MEE) issued a notice related to enterprise greenhouse gas emissions reporting tasks without mentioning plans to expand sectors in the CN-ETS. The investigation and rectification of carbon emission data quality issues in thermal power companies, exposed up to the end of 2021, are still ongoing. FE(2022) anticipated that the addition of other industries to the CN-ETS would be delayed by one to two years with cement and electrolytic aluminum initially expected to be included in 2023 at the earliest. Zhou (2024) believes that the priority order for expanding industry coverage includes cement, electrolytic aluminum, steelmaking, synthetic ammonia, refining, methanol, ethylene, calcium carbide, copper smelting, glass, papermaking, and steel processing. She suggests that these industries can be grouped into five batches for inclusion by 2030.Wang et al. (2024) anticipated that during the 14th Five-Year Plan period, the cement, civil aviation, and electrolytic aluminum industries will be prioritized for inclusion, while during the 15th Five-Year Plan period, the steel, papermaking, glass, petrochemical, and chemical industries will be gradually incorporated.On September 9, 2024, the MEE publicly solicited opinions on the "Draft Work Plan for the Inclusion of the Cement, Steel, and Electrolytic Aluminum Industries in the National Carbon Emissions Trading Market." According to the draft, the cement, steel, and electrolytic aluminum industries will be officially incorporated into the national carbon market within the year（MEE,2024）. The draft also points out that China has made clear arrangements to expand the coverage of the national carbon emissions trading market. The MEE has conducted research on the expansion work through methods such as enterprise surveys and expert consultations, comprehensively assessing the readiness of key industries—including steel, building materials, non-ferrous metals, petrochemicals, chemicals, papermaking, and aviation—for inclusion in the carbon market, and a timeline and roadmap for each industry’s integration into the market have already been established（MEE,2024）.

In general, the expansion of the CN-ETS to include additional sectors is anticipated to proceed. The precise sequence of sectoral inclusions will be contingent upon an array of factors. These factors encompass emission intensity, the dynamics of carbon pricing, the potential for emission reduction, the costs associated with management, data quality, the complexity of quota allocation, and the

influence of the European Union's Carbon Border Adjustment Mechanism (CBAM) (Karplus, 2020). It is worth highlighting that the acquisition of high-quality data emerges as one of the pivotal considerations in this context (Zhang, 2023).

3.2 Data quality issues encountered in expanding sector coverage in CN-ETS

The effective operation of the CN-ETS (China National Emissions Trading System) hinges on the availability of accurate and dependable carbon emission data (Zhang, 2020). China has made extensive preparations to include additional industries within the CN-ETS framework. To ensure the quality of data, the National Development and Reform Commission (NDRC) has taken a series of measures.

In 2013, the NDRC issued the first batch of greenhouse gas emission accounting methods and reporting guidelines (trial) for ten industry enterprises. These industries comprised iron and steel, chemicals, electrolytic aluminum, power generation, power grids, magnesium smelting, flat glass, cement, ceramics, and civil aviation (NDRC, 2013). Subsequently, in 2014, the NDRC released the second batch of guidelines, covering four industry enterprises: oil and gas, petrochemicals, independent coking, and coal production (NDRC, 2014). In 2015, the NDRC issued the third batch of guidelines, encompassing greenhouse gas emission accounting methods and reporting guidelines (trial) for ten industry enterprises. These sectors included papermaking and paper products, other non-ferrous metal smelting and rolling processing, electronic equipment manufacturing, mechanical equipment manufacturing, mining, food (tobacco and alcohol, beverages, and refined tea), public buildings, land transportation, fluorine chemicals, and other industries (NDRC, 2015). Furthermore, in January 2016, the NDRC explicitly stated that the CN-ETS would encompass eight key emission industries: petrochemicals, chemicals, building materials, steel, nonferrous metals, paper, electric power, and aviation (NDRC, 2016). Following the transfer of CN-ETS authority to the Ministry of Ecology and Environment (MEE) in 2018, the monitoring, reporting, and verification (MRV) of carbon emission data for these eight energy-intensive industries has continued (MEE[a,b], 2018). This ongoing effort underscores China's commitment to attaining high standards of data quality within the CN-ETS.

The eight CL-ETSs have been actively engaged in research and development of the MRV (Monitoring, Reporting, and Verification) system, aligning it with regional management systems and policy requirements(Duan et al., 2014). They have undertaken various significant initiatives in this regard. At the legislative level, all pilot programs have established corresponding MRV technical guidelines, and some have supplemented supporting management documents addressing aspects such as verification agency management and enterprise verification processes. For instance, pilots like Guangdong have devised comprehensive implementation details for MRV activities(Zeng,2016). Beijing and Shanghai have formulated specialized management measures for third-party institutions (Beijing MDRC, 2013;Shanghai MDRC,2014). Regarding the range of reporting industries, each pilot program gives precedence to industries characterized by substantial corporate emissions, particularly stationary source emissions such as electricity and cement. Industries that mainly emit from mobile sources, such as the transportation sector, have significant emissions but due to complex emissions management issues, are generally planned for inclusion at a later stage. However, the aviation sector in Shanghai and Guangdong and the public transportation sector in Beijing and Shenzhen is incorporated into their respective CL-ETS MRV systems (Shanghai MBEE, 2022; Guangdong PBEE, 2022; Beijing MBEE, 2022; Shenzhen CBEE, 2022).

To address the challenge of missing carbon emission calculation parameters for enterprises, various pilot regions have established a comprehensive set of default values for carbon emission calculation parameters. This approach ensures the feasibility of the MRV system. For instance, Guangdong has provided default values for emission factors related to 48 types of fossil fuels, marking it as the pilot program offering the most extensive set of default values for fuels. Additionally, in order to address situations where enterprises switch arbitrarily between actual measured values and default values to gain undue advantages, the Guangdong Pilot program became the first in China to introduce a third-party verification system for monitoring plans. If an enterprise changes a specific fuel emission factor from a measured value to a default value, it triggers alterations in the monitoring plan, necessitating a

rigorous verification process (Guangdong PBEE,2022). This significant development has notably enhanced the reliability and comparability of the data within the system (Busch et al., 2022).

It is not easy to obtain accurate data due to complex data accounting (Ayaz, 2017), even though China has been seeking for a long time to include more industries in the CN-ETS and has some experience in CL-ETSs. In the first compliance cycle of the CN-ETS, the quality of the carbon emission reports of the 2162 covered thermal power enterprises varies, and the quality of carbon emission data of many enterprises has a variety of problems (MEE,2022). Judging from some cases of carbon emission data falsification disclosed by the CN-ETS, many problems are related to the detection of the carbon content of coal-burning elements and the coal samples behind them. This is mainly caused by the policy of "high limit value " of carbon content in coal-burning elements in the CN-ETS, which stipulated that "…for enterprises that have not carried out actual measurement of the carbon content of coal-burning elements in 2019, the carbon content per unit calorific value is calculated as 33.56 tC/TJ" (MEE, 2019).

The value of 33.56 tC/TJ is the highest value selected from the default values of carbon content per unit calorific value of nearly 10 common domestic coal types (anthracite, bituminous coal, lignite, briquette, etc.). The default value of a briquette is also commonly called "high limit value" by the industry. The original purpose of the "high limit value" policy was to promote the actual measurement of carbon elements, and it did work. Survey data from the China Electricity Council showed the actual measurement rate of the carbon content of coal-burning elements in key emission units has increased from about 30% in 2018 to about 90% in 2022 after the introduction of this "high limit value" policy (CEC, 2022). But in practice, the "high limit value" policy, as implemented, has encouraged data falsification. The "high limit value" is about 20%-30% higher than the measured value of major coal-fired varieties (Zhang, 2022). For a power plant with an annual emission of 2 million tonnes, this difference will increase the compliance cost by 20-30 million yuan (at a carbon price of 50 yuan).

At the same time, due to the lack of effective regulatory measures and verification methods, some companies that are not ready for actual testing are faced with a dilemma. Either they are forced to use "high limit value", but they will pay high-performance costs for this, or they "collude" with some profit-seeking service agencies to forge or tamper with the test report, but once it is detected or exposed, it will face the risk of violation of laws and regulations of data falsification. Many coal-fired power plants face serious losses due to rising coal prices, at the same time, because of their social responsibility to ensure power supply, they are forced to use "high limit value" only because they have not measured the carbon content of coal-burning elements, resulting in a large gap in quotas. Some coal-fired power plants would increase tens of millions or even hundreds of millions of performance costs and encounter a situation of performance difficulties, so the motivation for counterfeiting is high. A more reasonable set of default values might have reduced the absolute incentives to cheat in this way or encouraged temporary acceptance of default valuations.

The eight CL-ETSs in China didn't introduce "high limit value " for the carbon content parameters of coal-burning elements in the carbon emission accounting process. CL-ETSs use the same group of major verification institutions as CN-ETS, and these CL-ETSs have been in operation for several years, with apparently no large-scale and systematic data falsification. This may be because the verification guidelines applied before March 2021 did not require verification agencies to verify the authenticity of all evidence materials by viewing the originals. In March 2021, the MEE issued the "Guidelines for the Verification of Enterprise Greenhouse Gas Emission Reports (Trial)" document, which strengthened the requirements for on-site verification, and proposed the requirement to consult the original certificate or save the original relevant evidence when going to the on-site verification (MEE,2021). But in fact, even if the verification agency has seen the original relevant certificates issued by the company, some so-called original certificates are also "carefully and professionally" falsified certificates, which are hard for the verification agency to guard against.

The above implies that MRV capacity needs to be improved. On the one hand, the inspection agencies are required to complete their work with high quality, and on the other hand, investment in the development of the inspection team is insufficient, and the regulation of the inspection industry is not in place. Although the responsible departments have expressed that they "attach full importance to

the verification work", the financial budget given to this key link to ensure the healthy operation of the carbon market is limited. By counting the prices and other information in the bidding announcements of various provinces and cities, the average cost of checking a company is 16,000 to 17,000 yuan, and some organizations have repeatedly quoted ultra-low prices of several thousand yuan to win the bid (Tang, 2022). Under these market conditions, the low price cannot support the recruitment and training of excellent talent limits the depth of the verification work. As a result, the phenomenon of "going through the motions" has occurred. What is required is a sufficiently well-funded system of monitoring, reporting and verification.

3.3 Working to improve data quality is still a work in progress

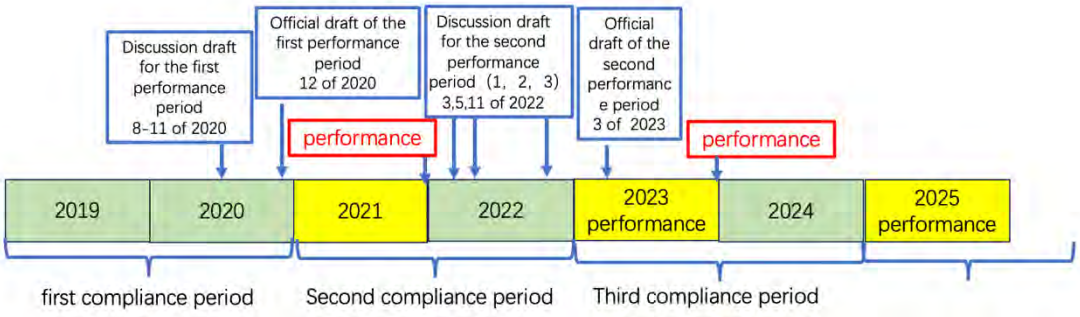

Fig.1. The compliance period and performance year for the CN-ETS

The end of 2023 marked the conclusion of the second compliance period for the CN-ETS. Enterprises were required to fulfill their quota compliance obligations for the period spanning 2021 to 2022 (Fig.1). To prevent the data quality issues experienced during the first compliance period, the Ministry of Ecology and Environment (MEE) initiated several actions.

Firstly, going on to complete the MRV institutional design. Combined with the actual operation issues of the CN-ETS in the first compliance cycle, MEE revised the technical specifications for the accounting and the reporting of greenhouse gas emissions for power generation facilities and prepared the technical guidelines for the verification of greenhouse gas emissions for power generation facilities. MEE adjusted the 33.56 tC/GJ “High Limit” to 30.85 tC/GJ “Medium Limit” in line with experts’ suggestions. In order to provide guidance for the quality assurance of carbon emissions, the MEE redesigned the MRV institutional arrangements and issued a series of documents. The MEE has also issued three discussion drafts of quota allocation for the second compliance period in March, May, and November 2022 continuously (MEE,2022a, 2022b, 2022c). The draft plan was released officially in March 2023 based on extensive consultation (MEE, 2023a, 2023b).

Secondly, data supervision has been further strengthened. On October 25, 2021, the MEE issued a notice titled *"Notice on Doing a Good Job in the Supervision and Management of Data Quality in the National Carbon Emissions Trading Market"* (Huanban Climate Letter [2021] No. 491). This directive mandates that all provinces, autonomous regions, and municipalities directly under the central government raise their awareness of the significance of data quality supervision and management within the CN-ETS. They are required to promptly conduct self-inspections of data quality and collaborate on the special greenhouse gas emission reports from the power generation industry. This collaboration encompasses law enforcement supervision and the establishment of a long-term mechanism for carbon market emission data quality management. These entities are further instructed to submit records of rectification work and self-inspection reports on data quality to the MEE by November 30, 2021(MEE,2021d).

Thirdly, various actions to improve data quality have been undertaken. Between 2021 and 2022, the MEE devised a special work plan and organized dedicated supervision and assistance efforts to assess the quality of CN-ETS emission reports. Cross-checks were conducted on 401 key emission units and 35 associated technical service agencies. Findings of problems and representative cases discovered through these efforts were publicly disclosed, and rectification measures were vigorously enforced. Since the issuance of the Carbon Monitoring Assessment Pilot Work Plan in September 2021, the first phase of the identified pilot tasks has been successfully completed. This has involved the

establishment of carbon monitoring networks from scratch, covering key industries, cities, and regions (MEE, 2022c). This comprehensive effort resulted in the construction of 93 online monitoring equipment stations for five pilot industries and the creation of 63 high-precision and 95 medium-precision urban monitoring stations (MEE, 2023c). Technical improvements to MRV methods have also been actively pursued, with the Carbon Monitoring Technical Steering Committee (under the MEE's purview) leading efforts to summarize technical methodologies and issue more than 10 carbon monitoring technical guidelines and procedures, spanning key industries, cities, regions, marine carbon sinks, and other domains.

In December 2022, the Ministry of Ecology and Environment (MEE) issued the "Technical Guidelines for the Verification of Corporate Greenhouse Gas Emissions from Power Generation Facilities" to standardize carbon emissions verification in the power generation industry. This initiative aims to improve the data quality of the national carbon market, unify industry understanding, and provide precise guidance for third-party verification activities.

To strengthen the daily regulatory mechanism for carbon emissions data quality, on February 7, 2023, the MEE released a notice regarding the management of greenhouse gas emissions reporting for the power generation industry for 2023-2025. This notice requires key emissions units included in the national carbon market's quota management to implement a monthly reporting system. Within 40 calendar days after the end of each month, these units must upload data on fuel consumption, product output, and supporting materials through a management platform. The revisions to the accounting and verification guidelines have significantly improved the level of data management.

On October 18, 2023, the MEE published a notice concerning the reporting and verification of greenhouse gas emissions for certain key industries from 2023 to 2025, specifically targeting the cement, aluminum smelting, and steel industries. This notice refined the emission accounting and reporting instructions at the facility (process/production line) level, revised the supplementary data accounting report template for carbon emissions, and clarified issues related to accounting boundaries and emission sources at both the process and corporate levels. It standardized accounting criteria, requirements, and methods, laying a solid data foundation for the forthcoming expansion of the national carbon market's industry coverage.

In January 2024, the CCER (China Certified Emission Reduction) program was fully resumed, with various methodologies released subsequently. The accounting guidelines for industries such as cement, steel, and aluminum smelting were also updated, providing a robust data foundation for the subsequent expansion of industry coverage.

3.4 What can China learn from abroad: slow is fast? or hurry up?

The deceleration in progress observed in the MRV, as well as the postponements of sectoral expansion within the CN-ETS, has triggered extensive discussions among experts. These deliberations are fundamentally focused on identifying strategies to accelerate the implementation of essential measures required for the enhancement and extension of carbon market pricing mechanisms in China, in the light of international developments, notably the implementation of the EU CBAM.

Some experts argue that ‘slow is fast’. The current pace, although seemingly slow in sectors expression, is appropriate and necessary. They contend that the construction of the ETS is a long-term project that is staged and continuously developed and improved (Hoffmann, 2007; Duan, 2015; Zhang, 2021; Pahle et al., 2023). Data quality problems exposed in the early stages of the operation of the carbon market must be viewed in context. Regarding data quality, early exposure of problems is not a bad thing if quality issues can be effectively solved (Zhang et al., 2021). The underlying reasons for emerging data quality problems is that companies lack an understanding of the issue of climate change and do not regard carbon reduction as their responsibility (Tang, 2022; Zhang et al, 2021). At the same time, corporate integrity issues, incomplete data quality supervision regulations, and insufficient supervision capabilities are also important reasons for data quality problems (Calel et al., 2023). The construction of MRV system is a common measure to ensure data quality (Andries et al., 2023).

Several factors contribute to the complexity and challenges in MRV for various industries at the moment (Mercer & Burke, 2023). For instance, the quality of carbon emission data from thermal power enterprises over the past two years remains under evaluation (Zhang et al.2022). Industries such as steel production involve multiple intricate processes, each with distinct sources of emissions that require precise calculation. Similarly, the chemical industry often employs diverse raw materials and processes to produce identical products, leading to variations in carbon emission factors (FE, 2022; Sang et al., 2023). The cement industry faces the daily monitoring of magnesium oxide and calcium oxide content in waste clinker, involving a complex measurement process and substantial volumes of data (Xu et al., 2022). Carbon emission accounting standards for industries like steel, chemicals, and cement are still evolving, introducing data accounting difficulties. Furthermore, many companies, aside from thermal power, lack the internal accounting capabilities to independently complete carbon emission reports and often rely on third-party agencies.

The CN-ETS is currently centered on carbon emission intensity control, meaning that carbon allowances for participating enterprises are closely linked to production volumes and methods, thus necessitating accurate output data. the gradual expansion of sectors in the CN-ETS is not necessarily a negative development. Over rapid expansion of the CN-ETS could exacerbate these issues and undermine the effective operation of the national carbon trading market. For example, in Phase 1 (2005–2007) of the EU ETS, a lack of accurate data resulted in an overestimation of future emissions, thereby resulting in an overallocation of allowances and a significant decrease in allowance prices (Betz et al., 2006;Betz & Sato,2010). As per the principle of the Ministry of Ecology and Environment (MEE) for expanding the carbon market sectors' coverage, it is crucial to consider the relationship between emission reduction and continuous development, emphasizing a step-by-step and fact-based approach. The current apparently slow behavior of the MEE in expanding the sectors is accompanied by necessary actions to, hopefully, lay a more solid foundation for improving the MRV system and improving data quality.

By contrast, there exists a viewpoint among experts advocating the need to ‘hurry up’ and accelerate the expansion of the CN-ETS, emphasizing its necessity to effectively meet carbon peak and carbon neutral targets and to uphold the international competitiveness of Chinese enterprises (Davidson et al., 2021; Busch et al., 2022; Magacho et al., 2023). The EU Carbon Border Adjustment Mechanism (CBAM) on officially came into force on May 17, 2023, with its application starting from October 1, 2023. This has underscored the critical imperative of aligning the CN-ETS with international developments and standards. CBAM aims to prevent carbon leakage, where EU companies move production outside the EU to places with looser climate policies. Under the CBAM framework, the EU seeks to reduce emissions by phasing out free allowances for specific energy-intensive products while imposing carbon import taxes on imports originating from jurisdictions lacking reciprocal carbon pricing mechanisms (ECCEU,2022). EU Economic Commissioner Paolo Gentiloni (Gentiloni, 2023) asserts that CBAM serves as an environmental policy tool rather than a tax or tariff, aligning with international trade regulations. However, it's worth noting that some experts consider CBAM as unilateral trade protection that may not adhere to the fundamental norms of international trade (Hufbauer et al., 2022). Moreover, the implementation of CBAM raises concerns about an increased administrative burden on EU customs authorities and foreign producers as it has the potential to lead to resource shuffling, whereby ‘greener’ production within exporting countries is allocated to EU markets without effecting global emissions. The extent and impact of resource shuffling post-CBAM implementation remains challenging to predict (Ritz, 2022).

While the EU-CBAM progressed through the legislative process in Brussels, the United States introduced its own version of a carbon border adjustment. In early June 2022, U.S. Senator Sheldon Whitehouse (Democrat representing Rhode Island) introduced the Clean Competition Act (CCA). The introduction of the CCA underscores the growing significance of carbon taxes and penalties concerning carbon emissions in international trade (McCabe, 2022). The CCA utilizes a baseline difference approach for carbon tax collection, penalizing producers importing into the U.S. if their carbon intensity exceeds industry baselines. This establishes a carbon border adjustment as a U.S. trade tool to incentivize deeper decarbonization among foreign producers while safeguarding U.S. firms. The primary objective of the CCA is to penalize producers with more carbon-intensive processes, providing a competitive advantage to U.S. firms with comparatively lower embodied emissions (Reinsch &Duncan, 2022).

Given China's status as the EU's second largest trading partner (after Russia) in the sectors covered by the CBAM, a considerable portion of Chinese exports (in the sectors covered by CBAM) may be impacted by CBAM. CBAM payment obligations for imported products depend on several factors, including carbon pricing levels, which currently exhibit significant disparities between the EU ETS and the CN-ETS. In 2022, the average transaction price of carbon emission allowances (CEA) in China's carbon market ranged between 50-60 yuan/tonne (6.6-7.9 Euro/tonne), while the average carbon price in the EU carbon market stood at 81 Euros/tonne (ICAP, 2023). This substantial carbon price differential implies that if Chinese products are taxed to compensate for this gap, CBAM will initially raise the export costs of carbon-intensive Chinese products, potentially affecting the quantity of exports of high-carbon products. As the scope of taxation expands, the impact on the export trade system, especially in energy-intensive industries, could grow.[1]

Carbon pricing has proven to be an effective climate policy; however, other strategies which China adapted, such as the implementation of Dual Control of Energy Consumption (Yan & Su, 2020)[2]. and participation in green electricity trading also contributes to carbon reduction (Lin & Qiao, 2023). Ritz (2022) suggests that second-best carbon prices can exhibit significant asymmetry across countries, influenced by market power dynamics. These alternative policies may not necessarily align with CBAM exemption clauses. Furthermore, it will take time for China and the EU to mutually recognize each other's data, raising questions about whether these carbon price expenditures can be acknowledged by the EU and subsequently deducted from the EU's carbon tariff (CBAM). Addressing these challenges necessitates an expansion of CN-ETS coverage to include industries like steel and aluminum, along with an increase in the CN-ETS carbon price (UNCTAD, 2021) and improvements in MRV. China must therefore recognize and adapt to significant international carbon policies to gain competitive advantages in global trade. This realization underscores the urgency of accelerating the expansion of sectoral coverage within CN-ETS. Expanding sectors' coverage within the CN-ETS aligns with the EU's expectations and aids Chinese enterprises in adapting to the implications of CBAM.

4. Suggestions for advancing carbon markets in China

4.1 China needs to pay attention to EU-ETS I, EU-ETSII, CBAM and CCA's timetable and prepare for it by 2034

China should pay attention to the timetables associated with the EU-ETS I, EU-ETSII, CBAM, and CCA and adequately prepare for their implications by 2034 (Fig.2).

[1] It is important to recognise that smaller African countries are much more proportionately effected by CBAM than China and developed countries like the UK are actually more proportionately effected than China (UNCTAD, 2021 and Magacho et al., 2023).

[2] The concept of "Dual Control of Energy Consumption" encompasses the concurrent management of energy consumption intensity and total energy consumption. Specifically, it involves the regulation of two key metrics: "energy consumption per unit of GDP" and "total energy consumption." The inception of the "Dual Control of Energy Consumption" policy can be traced back to the "Eleventh Five-Year Plan" era. During this period, the remarkable expansion of the national economy and the concurrent surge in energy consumption highlighted the increasing strain on finite energy resources. In April 2007, the National Development and Reform Commission introduced the "Eleventh Five-Year Plan for Energy Development." This pivotal document marked the first instance of articulating comprehensive targets for both controlling total primary energy consumption and reducing energy consumption per unit of GDP. Notably, the reduction in energy consumption per unit of GDP was established as a binding performance indicator. Subsequently, the "Twelfth Five-Year Plan" not only retained the reduction of energy consumption per unit of GDP as a binding performance metric but also introduced stipulations for judiciously managing total energy consumption. Notably, these developments aimed to address the challenges posed by burgeoning energy consumption and resource constraints. As the "Thirteenth Five-Year Plan" period unfolded, a more intricate framework known as "Dual Control" was implemented, targeting both total energy consumption and energy consumption intensity. The stipulations included an ambitious goal of reducing energy consumption per unit of GDP by 15% by 2020 compared to the 2015 baseline. Additionally, a cap was imposed on total energy consumption, with a target set at 5 billion tonnes of standard coal. To ensure regional alignment, the "Dual Control" objectives were disseminated and localized across various regions. Looking ahead to the "14th Five-Year Plan," there is a pronounced emphasis on refining and enhancing the dual control system governing total energy consumption and intensity. By 2025, the plan stipulates a reduction of 13.5% in energy consumption and an 18% decrease in carbon emissions per unit of GDP, relative to the 2020 baseline. Once again, the "Dual Control" objectives will be decentralized and operationalized at the regional level to ensure effective implementation across the nation.

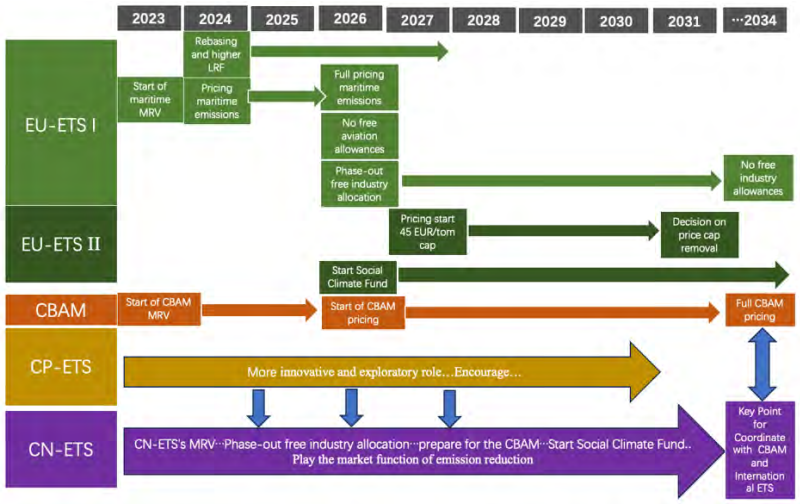

Fig.2 Time Table of EU-ETS I,II,CBAM,CL-ETS,CN-ETS in future

Currently, the existing EU ETS (which we label as EU-ETSI) covers around 36% of the EU's emissions. It covers the energy sector, industrial installations, and EU aviation (Jensen, 2023). Maritime transport will be the newcomer and large vessels of 5,000 gross tonnage and above must gradually surrender emission allowances (EUA) for an increasing share of their emissions: 40% in 2024, 70% in 2025 and 100% in 2026 (Göss,2023). The inclusion of smaller vessels and non-CO2-emissions such as methane and N_2O will likely start from 2026 onwards. Next to this new inclusion, the overall ambition of emission reductions until 2030 compared to 2005 under the EU ETS increased to 62% (EUC,2023a). To achieve this reduction EU legislators agreed on a rebasing of emissions: 90 million EUA are taken out of the market in 2024 with another 27 million EUA following in 2026 (ECCEU, 2023). In addition, the entire emission cap will be reduced by 4.3% annually from 2024 to 2027. From 2028 onwards this linear reduction factor (LRF) will rise to 4.4%. As expected, the market stability reserve (MSR) will continue to take out 24% of surplus EUAs (Marcu et al,2023).

Extending the EU ETS to road transport and heating fuels is another key component of a more stringent EU climate policy mix (Pollitt & Dolphin, 2021). A separate emission trading system will be introduced for emissions currently not priced across the entire EU (the new scheme is named EU ETS II) . This EU ETS II will include emissions from the building sector as well as from road transport and the usage of fuels in other, as of now not defined sectors. The EU ETS II will however only become operational from 2027 earliest (Vettorazzi & Medeiros,2022). EU had also built in a safeguard that would allow them to postpone the launch of EU ETS II to 2028 in the event of exceptionally high oil or gas prices in 2027. Substantial revenues from the auctioning of emission allowances in EU ETS II will be applied to the Social Climate Fund, which supports vulnerable groups of society to make sure the green transition leaves no one behind. It will be launched in 2026, a year ahead of the EU ETS II. The Social Climate Fund will aim to mobilise EUR 86.7 billion from 2026 to 2032. The rest of the EU ETS II revenues will go directly to Member States, who will spend the money on climate and social projects (EUC,2023b).

The EU Commission expects that about 75 million more EUAs (per year) will be auctioned due to the phase-out of free allocations to industry, increasing the auction income (Göss,2023;EUC,2023c). Half of that income should go into the EU Innovation Fund that supports these industries with the implementation of decarbonisation projects. The other half will be available for the EU member states to support their exporting industries. This leads to the next large updating of ETSI as the phasing out free allocations is tightly coupled with the introduction of the carbon border adjustment mechanism (CBAM). To begin with CBAM was to cover the most emission-intensive sectors: iron and steel, cement, fertilisers, aluminum, electricity. However new agreements from 13th of December 2022 also feature hydrogen, certain precursors and other downstream products such as screws and bolts(in steel or aluminum sector) as imports under CBAM (Méyère,2022). In addition, the EU Commission will assess the inclusion of other products that might be at risk of carbon leakages such as organic chemicals and polymers into CBAM from 2030 onwards. Indirect emissions at the production facility might also have to be part of the emissions to be reported and consequently paid for by importing

companies.

From October 2023 importers in the covered sectors must get ready to meet their monitoring, reporting and verification (MRV) obligations, which start over 2 years ahead of the pricing mechanism. The process of implementing the fully operational CBAM will begin on 1 January 2026, meaning that importers will then be required to buy carbon certificates. The price of a certificate will reflect the unit price of an EU ETS allowance, and at the end of each annual reporting cycle the importer will have to surrender an equivalent amount of CBAM certificates to reflect the price of the total embedded GHG emissions for any relevant goods it has imported over that year. As mentioned above, the price to be paid for the embedded emissions will be reduced by any amount the non-EU manufacturer has already paid in respect of those emissions in the originating jurisdiction (Böning, & Folger, 2023). The EU's phase-in plan for the CBAM includes the gradual decrease of the free allocation of EU ETS allowances over a nine-year period from 2026 to 2034 for the sectors covered by the CBAM. The gradual introduction of the CBAM will be directly linked to the phase out of the EU ETS allocations. and CBAM will be fully implemented in 2034 (CE, 2022).

The United States' CCA had 25 different sectors listed in the original bill, including prominent carbon-producing industries such as petroleum, natural gas, fertilizer, paper, cement, glass, and iron and steel (Reinsch &Duncan, 2022). Exporters of these industries would face fees based on their emissions intensity when entering the United States. If the CCA was passed, the carbon tariff would have been imposed starting in 2024 (McCabe, 2022). The bill has not been passed yet, and its implementation is uncertain.

Carbon-intensive producers will face a distinct disadvantage compared to more carbon-efficient regions, such as the EU and the U.S. The introduction of carbon tariffs by the EU and, potentially, the U.S. will reshape the competitive landscape across various industries. Both the EU and the U.S. are significant export markets for China, ranking as the second and third-largest destinations for Chinese products respectively (GS, 2021). Given this scenario, policymakers in China should pay attention to developments with EU-ETS I, EU-ETSII, CBAM and the CCA. 2034 is a significant date for the full implementation of CBAM. Expediting the development of CN-ETS and expanding its coverage, particularly to those sectors named in CBAM and CCA. China should collaborate with European Union and seize the challenge and opportunity presented by the CBAM. China should join with the European Union to champion the global expansion of carbon markets and carbon pricing, facilitating a climate club approach to promoting carbon pricing globally, thereby increasing the likelihood of realizing the overarching goal of global decarbonization (Nordhaus,2015; Pollitt,2019).

4.2 'Do not give up the whole forest for one leaf' or the importance of getting the basics right first.

China's commitment to enhancing the accuracy and quality of carbon emissions data is a commendable endeavor. However, it is imperative for Chinese policymakers and market participants to adopt a broader perspective and understand the overarching goals of the carbon market.

The primary objective of a carbon market is to employ economic mechanisms to incentivize cost-effective emissions reduction by enterprises within a context of achieving a scientifically based restriction the total quantity of emissions. Achieving decarbonization is a long-term and complex goal. Therefore, while striving for data accuracy, it is crucial to consider the effectiveness of the carbon trading market's implementation and to advance the development of the national carbon trading market on a global scale. For instance, lessons from the CL-ETS include scenarios where prices for purchasing additional allowances were lower than anticipated due to over-allocation of allowances. How will the new CN-ETS manage the scale of issuance of emission permits and create incentives for emissions reductions? As electricity pricing becomes more flexible, how can the carbon market and electricity market reforms complement each other? Moreover, how should China accelerate and expand market coverage, and how can enterprises align with green and low-carbon trends, formulate early low-carbon development strategies, and implement energy-saving initiatives to promote sustainable growth? These sorts of questions require careful consideration going forward.

The first imperative is to enhance the carbon emissions data statistics and accounting systems to

solidify the basis of the carbon market's operation. Utilizing the expertise of think tanks and aligning with globally recognized carbon emission statistics is an essential step. Promoting the adoption of carbon accounting methods and standards at the national, local, industry-specific, and product-specific levels is crucial. Additionally, fostering the adoption of internationally agreed standards and certifications is vital. Active involvement in the formulation and revision of international energy efficiency and low-carbon standards, along with seeking mutual recognition of standards across the industrial carbon chain with more countries, is paramount, if mutually recognized and trusted carbon markets are to advance globally in the fight against climate change.

The second requirement involves bolstering the legal framework for carbon market operations. This includes expediting legislation related to carbon emissions trading management and enhancing supporting regulations, technical specifications, and the carbon emission MRV system. Implementing measures for market supervision of carbon emission rights trading is essential. Clearly defining the responsibilities and obligations of market participants and developing stringent penalties for violations by third-party organizations are necessary. Improvements in the management of carbon emission rights trading, registration, settlement, and the formulation of additional supporting regulations and documents related to carbon emission accounting, reporting, and verification technology and management rules are also vital.

The third imperative centers on strengthening regulatory compliance within China's carbon market. Establishing access thresholds for third-party technical service organizations supporting controlled entities is crucial. Implementing a "clearance" mechanism and maintaining a register of approved technical service organizations and qualified personnel are essential for enhanced supervision. The introduction of cross-sectoral joint penalties for underperforming organizations – including deregistration - through improved information disclosure and reporting systems will enhance the monitoring and detection of potential issues in the carbon emissions trading market.

The fourth requirement focuses on elevating the capabilities of all market participants and enhancing professional training. Providing training opportunities for carbon market trading entities, access to experts, and technical personnel to interpret national carbon market laws, regulations, and technical specifications will strengthen the CN-ETS. Business training on carbon data management, carbon emission verification, and carbon market supervision improve their understanding of the various aspects of carbon markets in different industries. Furthermore, professional certification in carbon data verification and carbon asset management should be strengthened to create a pool of experts well-versed in carbon market mechanisms and trading tools, contributing to the overall development of the national carbon market.

4.3 Learning from the experience of MRV in China and the EU.

The establishment of a robust MRV system is a fundamental prerequisite for CN-ETS. Such a system is essential to instill confidence among market participants, facilitate the expansion of industries within the ETS, and garner international support and credibility. While China has made strides in enhancing the integrity of its MRV system, there is a pressing need for further improvements. It is imperative that the draft of the ETS law, currently at the State Council level, be expeditiously passed to address these concerns.[3]

The establishment of a robust certification system for verification agencies is imperative to ensure the consistency and quality of cross-provincial verification processes. It is equally crucial that verification fees are set at a level that enables thorough and effective verification procedures. Furthermore, there is a pressing need for clearer and more detailed regulations and guidelines in the MRV framework.

Accurate and reliable emission data serve as the foundation for Chinese exporters to adhere to the EU-CBAM through participation in the CN-ETS. It is important to note that China's MRV systems and standards for greenhouse gas emissions are not yet comparable to those of the EU (e.g.

3 On March 30, 2021, the MEE announced the "Interim Regulations on the Administration of Carbon Emissions Trading (Revised Draft)" on its official website, and public comments were solicited until April 30. This is the third time that Chinese officials have publicly solicited opinions on carbon trading legislation at the State Council level. Since then, the Interim Regulations on the Administration of Carbon Emissions Trading have been included in the legislative work plan for two consecutive years.

Heggelund et al., 2019).

To address these challenges, China should intensify its research on the EU carbon market system and standards, seeking to establish connections between the systems and standards of the EU-ETS (Engels et al., 2008; Jotzo, 2013). This is how to lay the groundwork for China's carbon emissions management in the future. Formulating and enhancing emission accounting guidelines for all sectors covered by CBAM, establishing a comprehensive carbon emission monitoring, reporting, and verification system, and creating a carbon information disclosure system that aligns with international standards are essential steps.

4.4 If CL-ETS can have an innovative and exploratory function, alongside the CN-ETS, they are to be encouraged.

The presence of innovative and exploratory functions within the CL-ETS (Carbon Trading Pilot Markets) and their coexistence with the CN-ETS (Chinese National Emissions Trading System) should be encouraged. This model aligns with international practices, such as the case of German ETS vs. EU-ETS and EU-ETS I vs. EU-ETS II.

Germany, an early participant in the EU-ETS since its inception in 2005, subjected its domestic high-emission industries, including electric power, steel, building materials, and aviation, to emission constraints. In 2021, Germany introduced a National Emissions Trading System (nEHS) for emissions outside the European Emissions Trading Scheme (EU-ETS) under its "Climate Action Program 2030." The German Emissions Trading Authority at the German Environment Agency oversees both systems. To avoid double compliance burdens, mechanisms were established to deduct emissions from the nEHS when the same emissions were subject to EU-ETS requirements. Alternatively, follow-up compensation measures could be applied for additional costs incurred in the nEHS. The European Union is also introducing a parallel, non-overlapping ETS. This is the position of ETS II for the transportation and construction industries from 2027.

The establishment of a national carbon market in China marks a new beginning. Enterprises within the national carbon market will no longer participate in the pilot carbon trading markets, while those covered enterprises outside the national market will continue to operate within the CL-ETS. The CL-ETS allows for the management of smaller enterprises. Local pilots like the one in Chongqing have expanded their coverage to include industrial enterprises with greenhouse gas emissions exceeding 13,000 tonnes of carbon dioxide equivalent or about 5,000 tonnes of standard coal in any one year from 2018 to 2020. Additionally, institutions like universities and hospitals, crucial to Beijing's emission reduction goals, can be managed within the CL-ETS as they cannot be immediately included in the CN-ETS.

The CL-ETS serves as an innovative and exploratory platform that caters to local conditions, generating valuable experiences for the CN-ETS. These experiences are particularly valuable in areas like quota allocation methods, MRV standard systems, and market operation management. The CN-ETS significantly benefits from the knowledge transfer between the national and local pilots.

Furthermore, CL-ETSs can explore new directions in carbon finance. For instance, while initial CN-ETS quotas are free and relatively loose, CL-ETSs can experiment with tighter quota distribution and the implementation of auction systems (Wang & Duan, 2022). The introduction of carbon auctions can help stabilize carbon market prices, control enterprise performance costs, ensure fair price formation, and provide liquidity to market participants. China has basically formed a multi-level carbon market system framework that combines mandatory and voluntary carbon markets,and CL-ETSs still can experiment with more trading style. Innovative financial products such as carbon funds (ADB, 2023), carbon custody (Shannon, 2022), carbon pledge financing (Yu et al.,2015), carbon crowdfunding (Kunkel et al., 2014), and carbon insurance (Phelan et al., 2010) can be developed to facilitate low-carbon enterprise development.

Another area where CL-ETSs can innovate is in public outreach and incentivizing innovation. By pioneering carbon inclusiveness, these pilots can integrate carbon compliance, carbon neutrality, and carbon inclusiveness into their platforms, promoting industrial transformation, ecological

improvements, and other public benefits. Public information platforms employing digital technologies like blockchain, big data, and the Internet of Things can be established to provide transparent information on carbon emissions permits.

Lastly, CL-ETSs can explore cross-regional transactions (Gao et al.,2019). For instance, Guangdong's role as a national carbon market "test field" can involve the research and implementation of online trading service measures, ultimately fostering the development of regional carbon markets, such as the Guangdong-Hong Kong-Macao Greater Bay Area and exploring mechanisms for connecting national and international carbon markets (Li, et.al., 2023).

5. Conclusion

Our investigation into the CN-ETS and CL-ETS markets reveals the progress that has been made with carbon markets over time in China. The move from CL-ETS pilots to a CN-ETS covering electricity generation is a globally significant development for carbon pricing and carbon markets. The intentions behind these developments are good, as they are designed to promote Chinese carbon neutrality and they recognize that a carbon market is a key pillar of any serious net zero climate policy.

The urgency to reduce emissions globally, including in China, is increasing. Therefore, it is essential to accelerate the rollout of effective decarbonization policies in China. The Chinese government is making encouraging progress in this area. A significantly expanded and strengthened CN-ETS could play a crucial role in this process, similar to the impact of the EU-ETS in Europe.

Our study highlights that monitoring, reporting, and verification (MRV) issues remain critical in China, and timely improvements in this area are necessary. We have outlined the positive steps the Chinese government is taking to address these challenges. Additionally, we see potential for CL-ETSs to serve as innovation labs for the development of carbon markets in China.

We contend that the introduction of the EU-CBAM acts as a catalyst for the evolution of the CN-ETS. It creates incentives to broaden the CN-ETS to encompass all sectors covered by the EU-CBAM, aligning with its implementation timeline. This alignment suggests that the EU and China should aim for full market coupling by 2034, establishing a unified carbon price across both regions by then. Such a move would benefit global decarbonization efforts and facilitate compliance with the EU-CBAM while minimizing transaction costs. If this coupling occurs, it would position China and the EU to collaboratively enhance the expansion of carbon markets and pricing worldwide, significantly increasing the likelihood of achieving global decarbonization goals.

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Appendix

Table 1: The sample of Interviewees

No.	Interviewee	Sample
1	Academic scholar in international ETS	3
2	Academic scholar in national ETS	3
3	Academic scholar in CP-ETS	2
4	Provincial-level ETS officer(Beijing)	2
5	Provincial-level ETS officer(Shanghai)	1
6	Provincial-level ETS officer(Shenzhen)	2
7	Provincial-level ETS officer(Hubei)	2
8	Provincial-level ETS officer(Tianjin)	1
9	Provincial-level ETS officer(Chongqing)	2
10	Provincial-level ETS officer(Guangdong)	2
11	Provincial-level ETS officer(Fujian)	2
Total		22