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Influence of market structures and market regulation on the carbon market
Case Study Report

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Abstract:

This report analyses the influence of the design features of China's pilot emissions trading systems (ETS) in the Province of Hubei and the Municipal City of Shenzhen and the development of the electricity markets on the quality of the carbon price signal. Based on publicly available data and expert interviews, we derive four main findings on the impact of carbon market design and the electricity market structure on the quality of the allowances price.

First, the pilot ETS in Hubei and Shenzhen have adopted very different design features due to the specific local circumstances and both pilot programs are designed to strike a balance between emissions reduction and economic development. Second, despite the overall completeness of the design features, the pilot ETS in Hubei and Shenzhen and the allowance prices are affected by the lack of clarity and enforcement of certain rules, as well as limited support from the central government. Third, due to strong government regulation of China's electricity sector, including the electricity markets in Hubei and Shenzhen, carbon pricing has played a very limited role in driving low carbon investments. Finally, the electricity sector reform since 2015 has led to the adoption of some ambitious plans to deregulate electricity pricing for certain end-users and establish a more market-oriented electricity trading market, which will create a level-playing field for carbon pricing. However, there are signs that the reform process has been guided by the political agenda to reduce electricity prices in the short term and thus the effectiveness of China's ETS in internalizing the carbon cost in the future will depend on the political acceptability of electricity price increases resulting from the strong carbon price signal.

This case study is part of the project "Influence of market structures and market regulation on the carbon market" that aims to investigate the interdependencies between carbon and energy markets in Europe, California, China, South Korea, and Mexico.

Kurzbeschreibung:

Dieser Bericht analysiert den Einfluss der Gestaltungsmerkmale von Chinas Pilot-Emissionshandelssystemen (EHS) in der Provinz Hubei und der Stadt Shenzhen sowie der Strommarktentwicklungen auf die Qualität des CO2-Preissignals. Auf der Basis von öffentlich zugänglichen Daten und Experteninterviews leiten wir im Folgenden vier zentrale Erkenntnisse zu den Auswirkungen der Gestaltungsmerkmale von CO2-Märkten und der Strommarktstruktur auf die Qualität des CO2-Preises ab.

Erstens weisen die Pilot-EHS in Hubei und Shenzhen aufgrund der spezifischen lokalen Gegebenheiten sehr unterschiedliche Gestaltungsmerkmale auf und zielen darauf ab, eine Balance zwischen Emissionsminderungen und wirtschaftlicher Entwicklung zu schaffen. Zweitens werden trotz ihrer vollständigen Ausgestaltung die Pilot-EHS in Hubei und Shenzhen sowie die damit zusammenhängenden CO2-Preise von der mangelnden Übersichtlichkeit und Durchsetzung bestimmter Regelungen und der begrenzten Unterstützung durch die chinesische Zentralregierung beeinflusst. Drittens hat die starke staatliche Regulierung des chinesischen Stromsektors, einschließlich der Strommärkte in Hubei und Shenzhen, dazu geführt, dass die CO2-Bepreisung nur eine sehr begrenzte Rolle bei der Förderung CO2-armer Investitionen gespielt hat. Schließlich hat die Reform des Elektrizitätssektors seit 2015 zur Verabschiedung einiger ehrgeiziger Pläne geführt, die die Deregulierung der Strompreisgestaltung für bestimmte Endverbraucher sowie die Etablierung eines marktorientierteren Stromhandelsmarktes vorsehen, was gleiche Wettbewerbsbedingungen für die CO2-Bepreisung schaffen wird. Allerdings spricht einiges dafür, dass der Reformprozess in erster Linie vom politischen Interesse getrieben wurde, die Strompreise kurzfristig zu senken. Daher wird die Effektivität von Chinas EHS in Bezug auf die Internalisierung der CO2-Kosten zukünftig insbesondere von

der politischen Akzeptanz steigender Strompreise abhängen, die mit einem starken CO2-Preissignal einhergehen.

Die vorliegende Fallstudie ist Teil des Projekts "Influence of market structures and market regulation on the carbon market" ", welches zum Ziel hat, die Auswirkungen der Marktstrukturen und Regulierungen auf CO2-Märkte zu identifizieren und die Abhängigkeiten von CO2- und Energiemärkten in Europa, Kalifornien, China, Südkorea und Mexiko zu untersuchen.

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List of abbreviations

CO_2	Carbon dioxide
CCERs	China Certified Emission Reductions
CEMS	Continuous emission monitoring system
CHP	Combined heat and power
CNY	Chinese Yuan
DRC	Development and Reform Commission
ETS	Emissions trading system
GHG	Greenhouse gas
KW	Kilowatt
KWh	Kilowatt-hour
MEE	Ministry of Ecology and Environment
MW	Megawatt
MWh	Megawatt-hour
NDRC	National Development and Reform Commission
NEA	National Energy Administration
SO_2	Sulphur dioxide
SOEs	State-owned enterprises
VAT	Value-added tax

Summary and conclusions

This report analyses the interaction of China's emissions trading pilot schemes in the Province of Hubei and the Municipal City of Shenzhen and their electricity markets along two main questions:

- How do the design features of the pilot programs affect the environmental effectiveness of the system and the quality of the carbon price signal?
- How do electricity market design features and regulation affect the carbon price induced abatement in the power sector?

In the following, we first summarize our most important findings and then draw some interim conclusions on the interaction of the two markets.

Impacts of carbon market design on the quality of the carbon price signal

The quality of the allowance price signal and the predictability are most affected by the lack of a long-term target and the design of the ETS regulations in Hubei and Shenzhen using an *ex-post* adjustment mechanism:

- **Volatility**: Volatile carbon prices are an indicator that a market is able to react to newly revealed information. Yet, excessive volatility makes it difficult for market participants to make abatement and trading decisions. Allowance prices in Hubei have not demonstrated excessive volatility or high levels of intramonth volatility. Shenzhen's ETS pilot scheme experienced some significant price fluctuations at the early stage but the overall allowance prices in Shenzhen have not demonstrated excessive volatility thereafter. The process of *ex-post* allocation adjustments and the open market design may have contributed to the low levels of price volatility.
- **Reflection of marginal abatement cost (MAC) in the price**: In theory, a high quality or undistorted allowance price equals the MAC of all market participants. In practice, two main elements of the pilot ETS design in Hubei and Shenzhen might result in a distorted price signal. These include the *ex-post* adjustment mechanisms and restrictions on the operation of the exchange resulting in unpredictable allowance prices.
- **Predictability**: The long-term predictability of the allowance price in Hubei and Shenzhen is impacted by the broader Chinese climate policy context as well as by specific elements of ETS design. Regulators in Hubei and Shenzhen are reluctant to set a long-term allowance budget given the uncertainty surrounding the longevity of the pilot ETS when the Chinese national ETS begins. Such regulatory uncertainty makes it difficult to form expectations surrounding future scarcity and therefore price levels.
- **Environmental effectiveness**: The environmental effectiveness of the pilot ETS in Hubei and Shenzhen Pilot is difficult to assess. This difficulty results from the lack of data surrounding verified emissions and the inherent challenge in attributing changes in emissions to a single policy instrument.

Impact of electricity market structure on the abatement induced by carbon prices

The electricity sector abatement induced by the carbon price depends on market structure and regulations and is extremely limited in Hubei and Shenzhen for the following reasons:

- **Capacity mix**: The existing capacity mix in Hubei and Shenzhen impacts the role of carbon prices for the dispatching of power plants as well as for investment decisions. Hubei's power generation is largely dominated by coal power and the administrative dispatch also favors coal power due to the underlying consideration of securing investment returns. Shenzhen's capacity mix relying mainly on gas generation implies much lower short-term abatement potential than Hubei in the form of coal-to-gas fuel switching. Shenzhen also relies on importing electricity from other parts of Guangdong and thus the impact of the carbon price through covering indirect emissions is rather small, unless the targets to reduce indirect emissions were to be set more stringently.
- **Pass-through of carbon cost to retail electricity prices**: Due to the strong government regulation of electricity pricing in China, the pass-through of carbon cost to retail electricity consumers in Hubei and Shenzhen is rather limited. Although the electricity sector reform in 2015 has given hope for creating a level playing field for carbon pricing, the effectiveness of the pilot ETS in internalizing the carbon cost in the future will depend on the political acceptability of electricity price increases resulting from the carbon price signal.
- **Complementary policies**: Companion policies play a key role in determining the importance of carbon prices and investment decisions. In both Hubei and Shenzhen, strong companion policies have been implemented to reduce the energy – and thus carbon – intensity of power generation. Direct regulation co-exists with the pilot ETS, in order to achieve emission reductions, which decreases the role of carbon prices for the electricity sector. The strong government support for renewable energy development in Hubei and Shenzhen has also reduced the role of carbon prices for investment decisions.

Impact of electricity market structure on the quality of the carbon price signal

From our observations on the pilot ETS and the electricity market structure in Hubei and Shenzhen, we can derive the following conclusions regarding the impact of the electricity market structure on the quality of the allowance prices.

First, in a regulated electricity market, the capacity mix is likely to impact the role of the allowance price for the electricity sector. The coal dominated fleet has more potential for the carbon price to induce a fuel switch but in practice this transformation has been curbed by administrative dispatch and strong government regulation in the power sector.

Secondly, the role of a carbon price in a regulated electricity market is very limited. The pass-through of carbon cost to retail electricity consumers is restricted due to the strong pricing regulation. In a regulated electricity market, the effectiveness of internalizing carbon pricing also depends on the political acceptability of electricity price increases resulting from the carbon price signal.

Finally, the companion policies are likely to influence the carbon price signal and its predictability. Policies granting subsidies for increasing renewable energy uptake and command-and-control measures aiming at enhancing energy efficiency have a strong impact on investment decisions and therefore reduce the role of a carbon price. Understanding the role of a carbon price requires locating the ETS in a policy mix and in a regulated electricity market the ETS design needs to be adjusted to reflect the electricity market structure and regulation in a country-specific context.

Zusammenfassung und Schlussfolgerungen

Dieser Bericht analysiert die Interaktion von Chinas Pilot-EHS in der Provinz Hubei und der Stadt Shenzhen und ihren Strommärkten entlang zweier Hauptfragen:

- Wie wirken sich die Gestaltungsmerkmale der Pilot-EHS auf die ökologische Wirksamkeit des Systems und die Qualität des CO_2-Preissignals aus?
- Wie wirken sich die Gestaltungsmerkmale des Strommarktes und seine Regelungen auf die durch das CO_2-Preissignal induzierte Emissionsminderung im Stromsektor aus?

Im Folgenden fassen wir zunächst unsere wichtigsten Ergebnisse zusammen und ziehen dann einige Zwischenfazits in Bezug auf das Zusammenspiel der beiden Märkte.

Auswirkungen der Ausgestaltung des CO_2-Marktes auf die Qualität des CO_2-Preissignals

Die Qualität des Preissignals für Zertifikate und seine Vorhersagbarkeit werden am stärksten durch das Fehlen eines langfristigen Ziels sowie die Ausgestaltung der EHS-Regelungen in Hubei und Shenzhen beeinflusst, die einen Mechanismus für die Anpassung der zugeteilten Zertifikate beinhalten:

- **Volatilität:** Volatile CO_2-Preise sind ein Indikator dafür, dass ein Markt in der Lage ist, auf neue Informationen unmittelbar zu reagieren. Eine übermäßige Volatilität erschwert es den Marktteilnehmern jedoch, geeignete Vermeidungs- und Handelsentscheidungen zu treffen. Die Zertifikatspreise in Hubei haben keine übermäßige Volatilität oder hohe Volatilität innerhalb eines Monats aufgewiesen. Innerhalb des Pilot-EHS in Shenzhen kam es zwar in der Anfangsphase zu erheblichen Preisschwankungen, im weiteren Verlauf wiesen die Zertifikatspreise in Shenzhen insgesamt jedoch keine übermäßige Volatilität mehr auf. Die nachträgliche Anpassung bei der Zuteilung von Zertifikaten und die offene Gestaltung des Marktes könnten hier zu einer insgesamt geringen Preisvolatilität beigetragen haben.
- **Widerspiegelung der Grenzvermeidungskosten:** In der Theorie entspricht ein qualitativ hoher oder unverfälschter Zertifikatspreis den Grenzvermeidungskosten aller Marktteilnehmer. In der Praxis allerdings könnten zwei Hauptgestaltungsmerkmale der Pilot-EHS in Hubei und Shenzhen zu einem verzerrten Preissignal führen: der Mechanismus zur Anpassung der zugeteilten Zertifikate sowie die Einschränkungen beim Betrieb der Handelsplattform, die jeweils unvorhersehbare Zertifikatspreisentwicklungen nach sich ziehen.
- **Vorhersagbarkeit:** Die langfristige Vorhersagbarkeit der Zertifikatspreise in Hubei und Shenzhen wird sowohl durch den allgemeinen Kontext der chinesischen Klimapolitik als auch durch spezifische EHS-Gestaltungsmerkmale beeinflusst. Die Regulierungsbehörden in Hubei und Shenzhen zögern, ein langfristiges Budget für CO_2-Zertifikate festzulegen, da die Langlebigkeit des Pilot-EHS von der Aufnahme des Betriebs des nationalen chinesischen EHS abhängt. Diese rechtlichen Unwägbarkeiten erschweren es, Erwartungen hinsichtlich der künftigen Knappheit der Zertifikate und damit ihres Preisniveaus zu treffen.
- **Umweltwirksamkeit:** Die ökologische Wirksamkeit der Pilot-EHS in Hubei und Shenzhen ist schwer zu beurteilen. Das resultiert aus dem Mangel an Daten zu verifizierten Emissionen

und der Herausforderung, Veränderungen in den Emissionsmengen einer bestimmten politischen Maßnahme zuzuschreiben.

Auswirkungen der Struktur des Strommarktes auf die durch die CO_2-Preise induzierte Emissionsvermeidung

Die durch den CO_2-Preis induzierte Emissionsminderung im Stromsektor hängt von der Marktstruktur und anderen Regulierungen ab und ist in Hubei und Shenzhen aus folgenden Gründen sehr begrenzt:

- **Kapazitätsmix:** Der bestehende Kapazitätsmix in Hubei und Shenzhen wirkt sich auf die Rolle des CO_2-Preises sowohl für den Dispatch von Kraftwerken als auch für Investitionsentscheidungen aus. Die Stromerzeugung in Hubei wird größtenteils von Kohlekraft dominiert und auch seitens des administrativen Dispatch wird Kohlekraft bevorzugt, um damit Investitionserträge zu sichern. Der Kapazitätsmix von Shenzhen, der sich hauptsächlich auf Gaserzeugung stützt, impliziert ein viel geringeres kurzfristiges Emissonsminderungspotenzial in Form einer Umstellung von Kohle- auf Gasstromproduktion als Hubei. Shenzhen ist außerdem darauf angewiesen, Strom aus anderen Teilen Guangdongs zu importieren, sodass die Auswirkungen des CO_2-Preises durch die Abdeckung der indirekten Emissionen eher gering sind, es sei denn, strengere Ziele zur Reduzierung der indirekten Emissionen würden festgelegt.

- **Umlage der CO_2-Kosten auf die Strompreise:** Aufgrund der starken staatlichen Regulierung der Strompreise in China ist die Möglichkeit der Umlage der CO_2-Kosten auf die Stromkunden in Hubei und Shenzhen eher begrenzt. Obwohl die Reform des Elektrizitätssektors im Jahr 2015 Hoffnungen genährt hat, dass gleiche Wettbewerbsbedingungen für die CO_2-Bepreisung geschaffen werden, wird die Wirksamkeit der Pilot-EHS bei der Internalisierung der CO_2-Kosten in Zukunft von der politischen Akzeptanz von Strompreiserhöhungen abhängen, die mit CO_2-Bepreisung einhergehen.

- **Begleitende Politikmaßnahmen:** Begleitende politische Maßnahmen spielen eine Schlüsselrolle dabei, welche Bedeutung CO_2-Preisen und Investitionsentscheidungen beigemessen werden kann. Sowohl in Hubei als auch in Shenzhen wurden seitens der Politik umfangreiche Maßnahmen eingeführt, um die Energie- und somit auch die CO_2-Intensität der Stromerzeugung zu reduzieren. Neben den existierenden Pilot-EHS gibt es andere direkte politische Maßnahmen, um Emissionsminderungen zu erreichen, was die Bedeutung der CO_2-Preise für den Stromsektor wiederum verringert. Außerdem hat die starke staatliche Unterstützung für erneuerbarer Energien in Hubei und Shenzhen ebenfalls die Bedeutung der CO_2-Preise für Investitionsentscheidungen verringert.

Einfluss der Struktur des Strommarktes auf die Qualität des CO_2-Preissignals

Aus unseren Beobachtungen der Pilot-EHS und des Strommarktdesigns in Hubei und Shenzhen können wir die folgenden Schlussfolgerungen zu den Auswirkungen der Struktur des Strommarktes auf die Qualität des CO2-Preises ableiten:

Erstens: In einem regulierten Strommarkt ist es wahrscheinlich, dass der Kapazitätsmix einen Einfluss auf die Bedeutung des CO2-Preises für den Stromsektor hat. Ist die Stromerzeugung in erster Linie von Kohle abhängig, so hat der CO2-Preis ein höheres Potenzial, um eine Umstellung auf andere Brennstoffe herbeizuführen. In der Praxis wurde diese Entwicklung allerdings durch administrativen Dispatch und starke staatliche Regulierung im Stromsektor gebremst.

Zweitens spielen CO2-Preise in einem regulierten Strommarkt eine sehr geringe Rolle. Die Umlage der CO2-Kosten auf die Endverbraucher ist aufgrund der starken Preisregulierung eingeschränkt. In einem regulierten Strommarkt hängt die Wirksamkeit der Internalisierung von CO2-Preisen auch von der politischen Akzeptanz von Strompreiserhöhungen ab, die mit dem CO2-Preissignal einhergehen.

Schließlich können auch begleitende politische Maßnahmen das CO2-Preissignal und seine Vorhersagbarkeit beeinflussen. So haben Subventionen zur Förderung von erneuerbaren Energien und politische Maßnahmen zur Steigerung der Energieeffizienz einen bedeutenden Einfluss auf Investitionsentscheidungen und reduzieren daher die Bedeutung des CO2-Preises. Um die Bedeutung des CO2-Preises verstehen zu können, muss das EHS in einen Policy Mix integriert werden. In einem regulierten Strommarkt müssen die Gestaltungsmerkmale des EHS zudem so angepasst werden, dass sie die spezifische Strommarktstruktur und dessen Regulierungen in einem länderspezifischen Kontext widerspiegeln.

1 Introduction

The project "Influence of market structures and market regulation on the carbon market" aims to identify the impact of market structures and regulations on carbon markets and to investigate the interdependencies between carbon and energy markets. In a first step, Acworth et al. (2019) identified major interaction channels based on a literature study. In the second step, case studies are used to analyse the mechanisms and interaction channels based on the previously developed framework. In this report, we present the case study for two Chinese pilot emissions trading systems (ETS) that differ in their carbon market design and that are at early stages with regards to their electricity market reform.

The aim of the China case study is to understand the interactions between ETS design and electricity market reform in China, with a focus on the two selected ETS pilot schemes in the Province of Hubei and the Municipal City of Shenzhen. China established seven pilot ETS projects in 2013, with the aim of establishing a national ETS through experimenting and learning. To date, the seven ETS pilots have been in operation in four municipalities (Beijing, Shanghai, Tianjin and Chongqing), two provinces (Hubei and Guangdong) and one independent planning city (Shenzhen). [1]

In December 2017, the National Development and Reform Commission (NDRC) adopted general rules governing the functioning of the national ETS for the electricity sector. These general rules establish an overarching regulatory framework and set key design aspects of the national ETS. However, the recent institutional restructuring of the Chinese government has transferred the regulatory authority of the national ETS from the NDRC to the newly established Ministry of Ecology and Environment (MEE). The major practical implication of this is that the momentum for developing the national ETS has been interrupted, largely due to the loss of expertise of some key stakeholders that were affected by the restructuring, and the coordination required between the Department of Climate Change and the MEE on issues related to climate policy and environmental policy.

The optimistic view of the Chinese ETS is that China's adoption of a market mechanism could result in the effective control of its greenhouse gas (GHG) emissions. However, considering the size and complexity of China's national ETS, the national government remains generally cautious about its impact. In a broader context, global and national socio-political and economic forces have delayed the introduction of China's ETS. The most significant of these forces include the announced withdrawal of the US from the Paris Agreement, ongoing and heightened US-China trade tensions, and the threat of recession in China and more broadly in the world economy – a threat increased by the spread of the Covid-19 virus in China and abroad.

In addition to the deteriorating economic situation, the challenges associated with the design of the national ETS and the non-market structure of China's electricity market architecture explain delays in the implementation of the national ETS. China is in the process of reforming the electricity market, with the objective of reducing command and control and gradually introducing competition. However, the deregulation of prices and investments based on the 'textbook' model of electricity market reform faces important challenges in an economy and a sector that have been – and continue to be – subject to heavy government intervention.

[1] The Province of Fujian opted in to implement an ETS pilot in December 2016, covering 9 sectors including electricity, petrochemical, chemical, building materials, iron and steel, nonferrous metals, paper making, aviation and ceramics. There were a total of 277 companies that met the threshold of coverage which is an annual energy consumption of 10,000 tons of standard coal and equivalent between 2013 and 2015.

In this context, the objective of the case study is to introduce the key design features that are essential to the effective functioning of an ETS in China by analysing the design features of the ETS pilot schemes in Hubei and Shenzhen. In addition, this report studies the interaction between electricity and carbon market regulation in China, by considering the objective of electricity market reform in China and its implementation in Hubei and Shenzhen.

The choice of Hubei and Shenzhen is justified based on two main considerations. First, the two localities represent different stages of development, and have different generation fuel mixes and industrial structures. Shenzhen has relatively low-energy intensive industries but the energy consumption from transport, residential and service sectors is increasing. By contrast, Hubei's GDP growth still largely relies on heavy industries that are energy and emissions intensive. The different economic and energy contexts are reflected in their different system design, making for an interesting comparison. Second, the two regions are at different stages in the market liberalisation of their electricity sectors. The differences across cases may therefore be insightful for the opportunities and challenges for emissions trading as China embarks on electricity sector liberalisation.

The methodology governing this study includes both desk-based document analysis and stakeholder interviews. Given the lack of public access to quantitative data (e.g. pricing and trading volumes) through official channels, the analysis is primarily based on qualitative methods. The document analysis is based on government policies and regulations. Moreover, to navigate the complexity of the regulatory framework governing carbon and electricity trading in China, we make use of the existing Chinese and international literature on ETS and electricity regulation in China. The interviews supplement the document analysis and provide, where necessary, primary information on the performance of the ETS pilot schemes and the reform process of China's electricity sector. We conducted 12 interviews and the interviewees included representatives from government agencies, energy companies, industry associations and research institutions (see table 16 in Appendix). The comments and feedback from the interviews are non-attributable and non-identifiable. Due to practical considerations (including generalising the information from interviews to ensure anonymity), in some cases the illustrative statements used in this report may not be verbatim direct quotations of interviewees' remarks.

Building on the analytical framework developed in the project (see Acworth et al 2019), the report is structured in three parts. First, we present the design features of the ETS pilot schemes in Hubei and Shenzhen (chapter two and four) and analyse their interaction with the quality of the price signal (chapter three and five). Second, we introduce China's electricity market regulation and its reform process, with a focus on the on-going reform since 2015 and its implications for electricity pricing. The third part of the report (chapter six and seven) analyses the implications of electricity market regulation in China (both pre-reform and post-reform) for the Chinese pilot ETS.

2 Design and Regulation of the Hubei ETS Pilot

Specific rules and regulations govern the operation of all pilot ETSs in China, which vary significantly across systems.[2] This chapter provides an overview of the design of the Hubei ETS pilot.

Launched in April 2014, the pilot ETS in Hubei is the second pilot program under China's ETS experimentation scheme. Hubei's ETS pilot covers around 45% of Hubei's total emissions, with liable entities from the power and industry sectors (ICAP, 2020). All liable entities, those consuming 60,000 tons of standard coal equivalent and above, are required to surrender one allowance or an eligible offset credit within a fixed limit for each ton of their verified GHG emissions before the end of May of each year.

Table 1 gives an overview of supply and demand side design features in Hubei's pilot ETS program. In the following chapter, we describe the individual design features in more detail. In chapter 3, we reflect on the design features' impact on the environmental effectiveness of the system and the quality of the allowance price signal along three dimensions: (1) price volatility, (2) reflection of the marginal abatement cost (MAC), (3) long-term predictability, and (4) environmental effectiveness.

Table 1: Overview Supply and Demand Side Design Features in Hubei's Pilot Program

Feature	Pilot ETS Design in Hubei	Comment
Allowance Cap	Absolute	Absolute cap: 270 Mt CO_2 (2020) The cap includes three components: • allowances for existing installations, • allowances for new entrants, and • government reserve of allowances.
Medium-term Target	2030 target at the national level: adopted	2030: reducing carbon emissions intensity by 60-65% from the 2005 level
Long-term Target	2060 target at the national level: recently announced	2060 target to achieve GHG neutrality; Hubei's pilot ETS does not contain either a short-term target or a long-term target
Primary Allocation (in electricity sector)	Initial allocation of 50% of the total allowances in the previous year and entities in the power sector receive the rest of the allowances based on their real output and benchmarks	Hubei has adopted an *ex-post* adjustment mechanism as part of the allocation method. Each year, before the end of the compliance period, the Hubei DRC will supplement or confiscate allowances if the difference between verified emissions and allocated allowances surpasses 20% or 200,000 tons.
Banking	Allowed with restrictions	Banking is generally not allowed except for allowances that have been traded in the market.
Borrowing	Not allowed	
Offsets	Up to 10% of entity's obligation	Eligible CCERs include those produced within Hubei and generated outside the emission boundary of liable entities.
Market Stability Mechanism	Price bounds	Instead of deploying a price floor or ceiling, Hubei assesses the trigger price of allowances through

[2] Zhang et al. (2014); Liu et al. (2015); Zhang & Xu (2017); Pang & Duan (2016)

Feature	Pilot ETS Design in Hubei	Comment
		monitoring the daily closing price of allowances in a period of 20 days. When the closing price reaches the highest or lowest bracket of the daily negotiating price range for a minimum of 6 days, the Hubei DRC has the obligation to consult with the Advisory Committee for its expert opinion.
Voluntary Cancellation	Allowed	
Coverage	~45% of provincial GHG emissions (2018)	Only CO_2.
Market participation	Open system	

2.1 Allowance supply

There are two main emission targets in Hubei. First, every five years, the province is assigned a reduction target under China's national emissions reduction target (which is intensity based). Second, the Hubei ETS has its own target on absolute emissions control. The following section discusses these two targets separately.

2.1.1 Allowance cap and long-term targets

During the 12th Five-year period (2011-2015), Hubei Province has saved 46.84 million tons of standard coal equivalent and reduced carbon dioxide emissions by 98.36 million tons. The total carbon dioxide emissions per unit of GDP in the province decreased by 20.1%, and the energy consumption per unit of GDP in the province decreased by 22.78% (Hubei Government, 2016, ch. 1). Under the 13th Five-Year period (2016-2020), Hubei's provincial target, under the allocation by the central government, is to reduce the carbon dioxide emissions per unit of GDP by 19.5% compared to the 2015 level, and the energy consumption per unit of GDP should be decreased by 16% compared to the 2015 level (ibid, ch. 2, section 3). Given the mid-term target to reduce carbon emissions intensity by 60-65% by 2030 from the 2005 level, Hubei's provincial government is expected to further reduce its carbon emissions and energy intensity in the coming years.

For the ETS pilot scheme, Hubei's emissions cap is set using a combination of historical and forward looking methods, taking into account the provincial target of reducing emissions intensity and the projected GDP growth (Hubei Government, 2013, part 3(2)(1)).[3] To reflect these considerations, the total cap in Hubei has three components, covering existing installations, new entrants, and the government reserve of allowances (see e.g., Hubei DRC, 2014, part 3(2)).[4] The historical emissions of the covered entities in the baseline years are the basis upon which the initial allocation to the existing and covered entities is decided, except for the cement, heating and power sectors (see e.g., Appendix 1, Hubei DRC, 2015a, part 4). In order

[3] Due to the government reshuffle, the managing authority of Hubei's ETS pilot has been transferred from the Provincial Development and Reform Commission (DRC) to the Department of Ecology and Environment (DEE). Given that the government reshuffle took place after the promulgation of majority of Hubei's ETS regulations, Hubei DRC is still referred to as the managing authority in a number of provincial regulatory and policy documents, but DEE is now in fact the managing authority of Hubei's ETS pilot.
[4] The allocation plans in 2015 and 2016 maintain the same composition of the cap.

to ensure the total number of allowances that are initially allocated to the covered entities is below the cap, Hubei adopts the market adjustment factor to reduce the sum of the allowances for initial allocation.[5] The predicted growth of emissions is used to set the boundary of emissions growth in Hubei for new entrants and production expansion of existing facilities. The government reserve puts aside no more than 10% of the total size of the cap (e.g. 8% in 2018 and 2017), which is then used for market stabilisation purposes (Hubei Government, 2013; Hubei DRC, 2014). As compared to other ETS pilots such as Beijing and Shanghai where the total cap is not publicly announced, Hubei has significantly improved the transparency of the cap by setting a clear and explicit cap at the beginning of each compliance period (see Hubei DRC, 2014, 2015a, 2016 and 2017).

According to the allowance allocation plans which have been released since 2014, the emissions cap of Hubei's ETS pilot scheme can be summarised as below. The overall trend is that the cap was reduced overtime from 2014 to 2016 but since 2017 the cap has increased slightly to accommodate the needs of the regulated entities (ibid).[6]

Table 2: The Emissions Cap of Hubei's ETS Pilot Scheme 2014-2018

	2014	2015	2016	2017	2018	2019
Annual Target (million tons of CO2)	324	281	253	257	256	270

Note: The cap includes three components including allowances for existing installations, allowances for new entrants, and government reserve of allowances. However, the Hubei ETS pilot does not publish information on the exact number of allowances under each of the component.

2.1.2 Initial allocation of allowances

The competent authorities set the annual total carbon emission allowances and formulate allowance allocation plans according to the province's economic growth and industrial structure optimisation and report these to the provincial government for approval. The total carbon emission allowances include the initial annual allowances for liable entities, allowances for new entrants, and government reserve allowances (Hubei Government, 2014, art. 11 & 2016b, art. 5).

Each year in June, the competent authority verifies the initial amount of allowances that each liable entity is entitled to, based on eligibility factors such as historical emissions and benchmarks. The allowances for new entrants are mainly used for new capacity and output changes. The initial allowances allocated each year as well as allowances for new entrants are distributed free of charge (Hubei Government, 2014, art. 13 & 14).

The authority of the Hubei ETS manages the process of allowance allocation through the allocation plans. The allocation plans essentially specify coverage of the ETS pilot including a list of liable entities, size of the cap and detailed allocation methods for different industrial sectors. Because the coverage of the ETS pilot expanded gradually and understanding of the allocation

[5] In the first compliance period, the market adjustment factor was 0.9192, and it was determined by the total emissions of the liable entities in 2010, multiplied by 97% then divided by the sum of the average emissions by the liable entities in the baseline years. In the subsequent compliance periods, the market adjustment factor is determined by the following formula: the factor = 1 – (the amount of remaining allowances held by the liable entities from the previous year / the total number of allowances of the current year). The adjustment factors in 2015 and 2016 are 0.9883 and 0.9856, respectively. See e.g., Appendix 1, "Allocation Plan" (2016), part 4 (1)(3).

[6] The total number of liable entities covered by the Hubei pilot program in 2017 is 344, 236 in 2016, compared to a total of 138 when the pilot first commenced operation in 2014.

methods improved over time, the allocation plan and rules were slightly adjusted each year and the below discussion focuses on the latest allowances allocation plan which was issued in July 2019. In 2018, the annual total emission allowances were determined according to Hubei's CO_2-intensity target and the economic growth forecast of the province.[7] The total carbon emission allowances for 2018 are 256 million tons (Hubei Government, 2019, part 3(1)). The allowances are distributed free of charge and are calculated using a range of methods, including benchmarking, historical intensity and historical emissions. Among their application in Hubei, the benchmarking method applies to the cement (except for clinker-type cement companies) and electricity sectors. The heat and cogeneration, papermaking, glass and other building materials and ceramics manufacturing industries rely on the historical intensity method, and the allocation method based on historical emissions is applied to all other industries. The detailed calculation under each of the methods considers a range of factors such as real output, a market adjustment factor, and an industrial emission control co-efficient (ibid, part 4(1)). The market adjustment factor and the industrial emission control co-efficient are further discussed below.

Auctioning

For price discovery, a small share of the reserve is available for auction. The revenues from auctions are used to support the government activities related to emissions reduction, to buy allowances back from the market, and for carbon trading market construction (Hubei Government, 2014, art. 15). Hubei conducted one auction before the commencement of the ETS pilot to test the market reaction. The auction was held in 2014 with a total of 2 million allowances sold at a price of 20 CNY (2.53 EUR) (Tanjiaoyi Website, 2014). Another two auctions were held on 27 and 29 November 2018, respectively, by using the allowances in the government reserve (Tanjiaoyi Website, 2019). The first auction sold 1.49 million tons of allowances with an average price of 24.65 CNY (3.12 EUR) (ibid). In the second batch, 3.51 million tons of allowances were auctioned, and the average price was 24.49 CNY (3.10 EUR) (ibid).

Benchmarking

In 2018, the allocation of allowances for the electricity and cement sector (except for clinker-type cement companies) is based on the following method:

*Initial allocation = actual allowances allocated in 2017 * 50%*

*Final and actual allocation = real output in 2017 * industry benchmark value * market adjustment factor*

a) The benchmark value of cement enterprises is set at the 40th most emission intensive enterprise in the Hubei Province in 2018. The specific benchmark value is determined based on the verification data of that year (Hubei Government, 2019, part 4(3)).

b) The selection criteria for the benchmark value of each unit of a coal-fired power plant is the advanced value among ultra-supercritical units and supercritical 600MW units.[8] For supercritical 300MW units and sub-critical units, the benchmark is set on the basis of the most advanced value of the same type of units in the province. The power generation

[7] See above section 2.1.1 on allowance cap and long-term targets.

[8] A supercritical steam generator is a type of boiler that operates at supercritical pressure. In contrast to a subcritical boiler in which bubbles can form, supercritical and ultra-supercritical power plants operate at temperatures and pressures above the critical point of water, i.e. above the temperature and pressure at which the liquid and gas phases of water coexist in equilibrium, at which point there is no difference between water gas and liquid water. Supercritical and ultra -supercritical power plants require less coal per megawatt-hour, leading to lower emissions, higher efficiency and lower fuel costs per megawatt.

enterprises using natural gas and other fuels are subject to a benchmark value equal to the weighted average of the carbon emissions per unit of electricity generated during the baseline years. The real output of electricity, heat and cogeneration is determined based on the total amount of electricity generation and the calculation method is as follows:

Total electricity generation = electricity generated + heat/heat and electricity conversion rate

In 2018, the heat and electricity conversion rate was 3.6 GJ/MWh (ibid).

Historical Intensity

In 2018, the heat and cogeneration, papermaking, glass and other building materials and ceramics manufacturing industries relied on the historical intensity method and the allowances allocation was calculated as below:

*Initial allocation = actual allowances allocated in 2017 * 50%*

*Final and actual allocation = actual production in 2017 * historical carbon intensity value * industry emission control coefficient * market adjustment factor*

The historical carbon intensity value is equal to the weighted average of the carbon intensity of liable entities in the same industry during the baseline years of 2015-2017 (ibid).

Grandfathering

In 2018, grandfathering applied to all other industries to determine their amount of allowances, according to the method below:

*Initial allocation = actual allowances allocated in 2017 * 50%*

$$\text{Final and actual allocation} = \text{historical emissions} * \text{industry emission control coefficient} * \frac{\text{market adjustment factor}}{365} * \text{normal production days}$$

The historical emissions are the arithmetic average of the total emissions that ETS entities released in the baseline years 2015-2017.

Ex-post Allowances Adjustment Mechanism

Hubei applies an *ex-post* adjustment mechanism to control the risks of over- or under-supply of allowances in the market. In practice, the adjustment mechanism is implemented through the process of allowance allocation. The general rule is that Hubei DRC has the authority to supplement or confiscate allowances if the verified emissions of an entity differ greatly from the number of allowances that have initially been allocated (ibid). Each year, before the end of the compliance period, the Hubei DRC will supplement or confiscate allowances if the difference between verified emissions and allocated allowances surpasses 20% or 200,000 tons. The amount to be supplemented or confiscated is the number of allowances that are beyond the threshold of 20% or 200,000 tons.

In practice, a number of allowances amounting to up to 50% of the installations' average emissions in the baseline years (ibid)[9] are allocated in advance (ibid, part 4(1)(1)). Before the

[9] The determination of the baseline year is based on the changes of carbon emission boundary and the total emissions volume of the liable entities in a given time frame. In 2018, for example, the baseline year is 2015-2017 and it is adopted as follows: (a) if the enterprise did not experience significant changes in carbon emissions due to increase or decrease of facilities (or changes of energy types of consumption) during the period of 2014-2016, the baseline year is 2015-2017; (b) if the enterprise experienced significant changes

end of a compliance period, entities in these sectors receive the rest of the allowances based on their realised output and the benchmark (ibid). By doing so, Hubei's pilot program aims to achieve a slightly tighter allocation in the initial round. The Hubei DRC reserves allowances for new entrants and capacity increase through the *ex-post* adjustment mechanism.

The market adjustment factor is used to determine the final allowances allocation. In Hubei, the below method is used to determine the market adjustment factor:

$$Market\ adjustment\ factor = 1 - \frac{market\ stock\ of\ allowances\ in\ previous\ year}{total\ carbon\ emission\ allowances\ allocated\ initially\ in\ the\ current\ year}$$

The market adjustment factor for 2018 was set at 0.9927 (Hubei Government, 2019, part 4(1)(4)).

In addition to the market adjustment factor, the industry emission control coefficient is used to determine the emission allowances for liable entities in all industrial sectors, except electricity and heat. It is determined by taking into account, inter alia the emission reduction cost, emission reduction potential, industry competitiveness, and historical trends of carbon emissions, across all different industrial sectors (see table 3) (ibid, annex 1-1-). As indicated by the interviewees, this is one of the areas that can be subject to government intervention.

Table 3: Industrial Coefficient under Hubei's ETS Pilot Scheme in 2018

Industry	Industry control coefficient	Industry	Industry control coefficient
Electricity and heat cogeneration	--	Heat and cogeneration	0.9470
Glass and other building materials	0.9575	Cement	0.9578
Ceramic manufacturing	0.9576	Textile	0.9408
Automotive manufacturing	0.9363	Chemical	0.9403
Equipment manufacturing	0.9363	Non-ferrous metals and other metal products	0.9432
Steel	0.9638	Food and beverage	0.9331
Petrochemical	0.9671	Pharmaceutical	0.9310
Water production and supply	0.9671	Paper-making	0.9656

Source: Notice of Department of Ecology and Environment of Hubei Provincial Government on the Allowances Allocation Plan in Hubei Province in 2018.

in carbon emissions due to increase or decrease of facilities (or changes of energy types of consumption) during the period of 2015-2017, the entity's carbon emissions from the month of continuous production with the latest production capacity to the end of 2017 will be used as the basis for calculation. If the normal production days after the change are less than one year, the average carbon emissions in normal production days are to be converted to annual total emissions as the basis for calculation.

2.1.3 Banking and borrowing

Borrowing is banned in the Hubei ETS. Banking is generally not allowed except for the allowances that have been traded (Hubei DRC, 2016, part 4 (1)(3)). This means that if the remaining allowances held by the liable entities, after surrendering for compliance, are obtained through trading, these allowances can be banked for use in the following year. Otherwise the allowances will be cancelled at the end of the compliance year. This unique design of banking in Hubei's pilot program is to encourage trading of allowances, thus increasing the liquidity of the market.

2.1.4 Provisions for additional allowances supply

Offsets

China Certified Emission Reductions (CCERs) that meet the following conditions can be used for compliance purposes under Hubei's ETS pilot scheme:

a) CCERs that are produced within the administrative region of Hubei Province;

b) CCERs that are generated outside the emission boundary of liable entities that are regulated by the Hubei ETS pilot scheme.

The volume of CCERs for compliance may not exceed 10% of the ETS entity's initially allocated allowances. One unit of CCER is equivalent to one unit of emission allowance (Hubei Government, 2014, art. 18). The CCERs can also be traded in the carbon emissions trading market (ibid, art. 24). Unfortunately, there is no compiled information on prices and usage of CCERs in Hubei.

Linking

The Hubei Pilot ETS is not linked with other markets.

2.1.5 Market stability mechanisms

The price stability mechanism in Hubei's pilot program consists of auctioning (Hubei DRC, 2015b, ch. 3) and the buy-back of allowances (ibid, ch. 4), so as to ensure the stability of the carbon price.

The Hubei DRC is the administering authority of the stability mechanism and it has the regulatory authority to initiate, coordinate and supervise the implementation of auctioning and buying-back (ibid, art. 5, para. 1).[10] Instead of deploying a price floor or ceiling, the pilot program in Hubei assesses the trigger price of allowances through monitoring the daily closing price of allowances for periods of 20 days (ibid, art. 7, para. 1). When the closing price reaches the highest or lowest bracket of the daily negotiating price range for a minimum of 6 days within that period, the Hubei DRC has the obligation to consult with the Advisory Committee for its expert opinions (ibid).

The Advisory Committee is composed of government officials, regulators and researchers from a range of government agencies and research institutions (ibid, art. 6).[11] It is tasked with monitoring the market performance and price stability of Hubei's pilot program and, most importantly, with assessing whether the Hubei DRC shall conduct auctioning or buy back allowances (ibid, art. 6). As stipulated by the *Interim Measures* that underpin the market stability

[10] Please note that the managing authority of Hubei ETS pilot has been transferred from Hubei DRC to DEE.

[11] These agencies and institutions include but not limited to provincial finance department, pricing bureau, and research institutions, such as university.

mechanism in Hubei, the Hubei DRC shall gather members of the Advisory Committee to vote for a decision within 2 days if these price trigger conditions are met (ibid, art. 7). A valid resolution by the Advisory Committee requires a two-thirds majority to pass and the resolution is required to address the status quo of market performance, the amount of allowances to be auctioned or bought back, and the expected market performance afterwards (ibid, art. 8). The Hubei DRC is required to consult the Advisory Committee on measures to be taken to stabilise the carbon price (in particular the auctioning or buying back of allowances), but the Hubei DRC remains the ultimate decision-maker (ibid, art. 7). Once a decision is made by the Hubei DRC, the Hubei Emission Exchange is required to strictly carry out that decision (ibid, art. 5, para. 2. See also Hubei Emissions Exchange, 2016a).

In sum, the Hubei DRC – and not the independent Advisory Committee – has complete discretion concerning intervention with the market. This exposes the market to heavy government interference (Boute & Zhang, 2019). A study of China's SO_2 pilot trading schemes has previously highlighted the risks of heavy government interference with the functioning of emission trading (see Tao & Mah, 2009).

Implementation

Hubei's pricing regulation mechanism has not yet been utilised. However, when the allowance price in Hubei plummeted for a consecutive three days in 2016, the Hubei DRC intervened to stop the price from dropping further by suspending trading, without following the prescribed rules.

Referring to this event, some interviewees confirmed the concerns expressed in the literature on the risk of government interference with the market. The 2016 intervention by the Hubei DRC was considered inappropriate. By intervening with the market and not following the relevant pricing regulation rules, the regulator jeopardised the credibility of the ETS.

2.1.6 Voluntary cancellation of allowances

Hubei's ETS pilot allows voluntary cancellation of allowances, but neither individuals nor environmental groups have exercised voluntary cancellation in practice.

2.2 Demand

2.2.1 Coverage

The Hubei ETS covers industrial enterprises in the province with an annual comprehensive energy consumption of 60,000 tons or above of standard equivalent coal (Hubei Government, 2014, art. 23). According to the latest allocation plan, 338 enterprises in 16 industrial sectors were identified as liable entities to be covered by the Hubei ETS pilot in the compliance period 2018-2019 (Hubei DRC, 2018, Annex I) compared to 138 entities when the pilot first commenced operation in 2014. The 16 covered industries include electricity, steel, cement, chemical, equipment manufacturing, papermaking, water supply, glass and other building materials, food and beverage, automotive manufacturing, non-ferrous metals and other metal products, heat and cogeneration, textile, pharmaceutical, petrochemical and ceramic manufacturing.[12] The Hubei ETS only covers carbon dioxide emissions (Hubei Government,

[12] The 344 enterprises are located in Wuhan (61), Huangshi (29), Huanggang (16), Xiangyang (38), Qianjiang (9), Yichang (63), Xiaogan (23), Ezhou (11), Xianning (12), Jingmen (32), Jingzhou (17), Shiyan (17), Enshi (5), Suizhou (2), Xiantao (3).

2014, art. 52, para. 1). The lack of transparency with respect to Hubei's total emissions makes it very difficult to assess the coverage of emissions by the ETS.

2.2.2 Market participation

The Hubei ETS pilot is designed to be an open system which allows individuals and non-regulated entities, including individual and institutional investors to hold and trade allowances. As for trading, both OTC trading and trading on the Hubei Emissions Exchange are allowed. Among the seven ETS pilots, the Hubei ETS has the highest number of individual investors but their participation in trading activities is still unknown (Guangzhou Emissions Exchange and ICIS, 2017). In practice, the majority of trading takes place on the Hubei Emissions Exchange and trading on a bilateral basis mainly concerns the trading of CCERs.

2.3 Transaction and market oversight rules

The competent authority, together with the relevant departments, has established a risk management mechanism in Hubei to avoid significant fluctuations in trading prices and systemic market risks (Hubei Government, 2014, art. 29). The ETS regulator explicitly bans market disruption through manipulating supply and demand and issuing false information (ibid, art. 30).

The Exchange has also adopted relevant rules for market oversight to stabilise allowance prices and avoid market disruption (Hubei Emissions Exchange, 2016b, art. 47-52; Wang et al., 2019). The following rules have been stipulated for price stabilisation:

a) If the closing price of transactions by the same party reaches the highest or the lowest price in the daily negotiation price range involving all transactions for three consecutive trading days, the Exchange reserves the right to suspend the transaction from 9:30-10:30am on the fourth trading day and issue a warning notice;

b) Within 20 consecutive trading days (D1-D20), if the closing price reaches the highest or the lowest price of the daily negotiation price for an accumulated 6 days, and if the closing price on the 20th day (D20) has increased or decreased by 30% or more compared to the first day (D1), the Exchange shall adopt special measures. The special measures may include identifying public transactions made by the participant on the platform and confining the price adjustment within the limit of ±5%. These measures shall be applied for a period of 20 trading days. If the closing price on the day after terminating the special measures is 30% higher or lower compared to D1, the special measures will continue to apply (Hubei Emissions Exchange, 2016b, art. 47).

To avoid market abuse, the Exchange can adopt risk control measures such as, but not limited to, adjusting the price limit of the target price range and restricting deposits and withdrawals. If the market participants seriously violate rules related to market oversight, the Exchange has the right to request corrections and take measures to suspend their access to trading, to restrict transactions, and to cancel their trading qualifications (ibid, art. 48-52).

2.3.1 Legal nature of allowances

To date, the legal nature of emission allowances is still left undefined under the relevant ETS regulatory framework but the scholarly discussion on this topic is abundant. In terms of the legal status and nature of allowances, there are diverse opinions among Chinese scholars. The disagreement generally centres on whether the nature of allowances is more government-oriented or market-oriented. The definition also influences how the Chinese legal system on carbon trading should be designed. Most scholars argue that the legal nature of allowances is a quasi-property right, largely due to the scarcity and certainty of the number of allowances defined by the cap, as well as their disposability and tradability (see e.g., Wang et al., 2010; Deng, 2007). Others agree to define a carbon-emission allowance as a quasi-property right, but they also identify it as an environmental right, representing the economic value and ecological value, respectively (Ding & Pan, 2012). While defining a carbon emission right as a property right has great benefits in optimising the allocation of climate resources, there are concerns about the risk of transforming public resources into freely gained private assets under the current allowance-allocation system (Zhang, 2011).

2.3.2 Fiscal nature of allowances

In Hubei, the fiscal nature of allowances was left undefined for many years due to the lack of official clarification by the central government agency on this issue. However, according to the Interim Regulations on Accounting Matters related to Carbon Emissions Trading which was issued by the Ministry of Finance on 16 December 2019, allowances are now defined as intangible assets and specific rules regarding accounting practices apply when acquiring and selling allowances (Ministry of Finance, 2019).

With respect to accounting, the positions of allowances need to be documented as a separate group under intangible assets. Depending on the nature of allowances and their usage, various accounting requirements may apply. Freely allocated allowances and such allowances as are used for compliance purpose or subject to voluntary cancellation are not required to be booked into the accounting sheet (ibid, part 4). Freely allocated allowances that are sold in the market are treated as non-operating income and must be booked as other receivables under bank deposit in the balance sheet (ibid). Acquired allowances from the market must be documented in the accounting sheet at the date of acquisition with the acquisition price (ibid). When the acquired allowances are used to fulfill the obligation of the liable entity, they are considered a non-operating expenditure and must be booked into the accounting sheet accordingly (ibid).

2.3.3 Tax treatment rules for allowances trading

For many years during the ETS operation, there were no clear rules regarding the tax treatment of revenue generated from selling allowances. Several interviewees comment that this is one of the significant barriers to increasing the trading volume of allowances. Liable entities are not willing to sell allowances because doing so generates complexity for accounting purposes. As discussed above, this issue has been properly addressed by the Interim Regulations on Accounting Matters related to Carbon Emissions Trading. This is an important step forward in preparation for the national ETS. Concerning tax treatment, both the value-added tax (VAT) and corporate income tax may apply when the allowances are traded in the market. VAT is applicable to the transfer of allowances in the secondary market. Corporate income tax may also apply when the allowances are sold in the market.

2.3.4 Market places

The Hubei Emissions Exchange is the official trading platform where trading of allowances in Hubei takes place. Market participants include domestic and foreign institutions, enterprises, organisations and individuals (except third-party verification agencies and settlement banks), who can participate in the trading of allowances on the trading platform after registration with the Exchange. Transactions can be made through negotiation and/or fixed pricing. The Exchange is also the implementation agency for auctions in Hubei. For the time being, trading of derivatives is not allowed, although Hubei has been experimenting with trading of emissions futures. The transaction volume of futures is very small due to the uncertainty of Hubei's ETS remaining duration when the national ETS starts operation.

2.3.5 Transparency regulation

As compared to some ETS pilots, Hubei has improved the transparency of the cap by publishing the size of the cap annually through the allowance allocation plans. However, the environmental effectiveness of the cap can be compromised by the lack of transparency surrounding the total number of allowances being freely allocated to liable entities. In addition, price transparency is at stake because of the limit on the number of stock exchanges, including trading of allowances, imposed by the State Council (State Council, 2012). Trading of allowances at the Hubei Emissions Exchange is banned from instant transaction and clearance. The impact is that price discovery is limited and price transparency (price published by the exchange) can hardly reflect the full picture of the trading activities in the previous day and there is no systematic publicity of information regarding allocations, verified and surrendered emissions by installation, or the use of CCERs.

3 Assessing the ETS Design and the Quality of the Allowance Price in the Hubei ETS Pilot

Due to the limited access to information, the allowance prices in Hubei are tabulated using information from a secondary source as well as the aggregated data published by the Hubei Emissions Exchange.[13] The annual overview of spot transactions in Hubei is as below.

Table 4: Annual Overview of Spot Transactions in Hubei's ETS Pilot Scheme

Type of allowance	Year	Highest (CNY)	Lowest (CNY)	Trading volume (Tons)	Turnover (CNY)
HBEA	2019	29.50 (average price) (3.73 EUR)		6,128,611	180,772,065.00 (22,886,322.00 EUR)
HBEA	2018	33.77 (4.28 EUR)	13.24 (1.68 EUR)	9,050,697	208,710,708.82 (26,423,051.40 EUR)
HBEA	2017	17.99 (2.28 EUR)	11.50 (1.46 EUR)	12,729,939	186,459,299.00 (23,607,542.00 EUR)
HBEA	2016	23.70 (3.01 EUR)	-	11,274,900	-
HBEA	2015	-	-	13,941,508	-
HBEA	2014	-	-	8,981,413	-

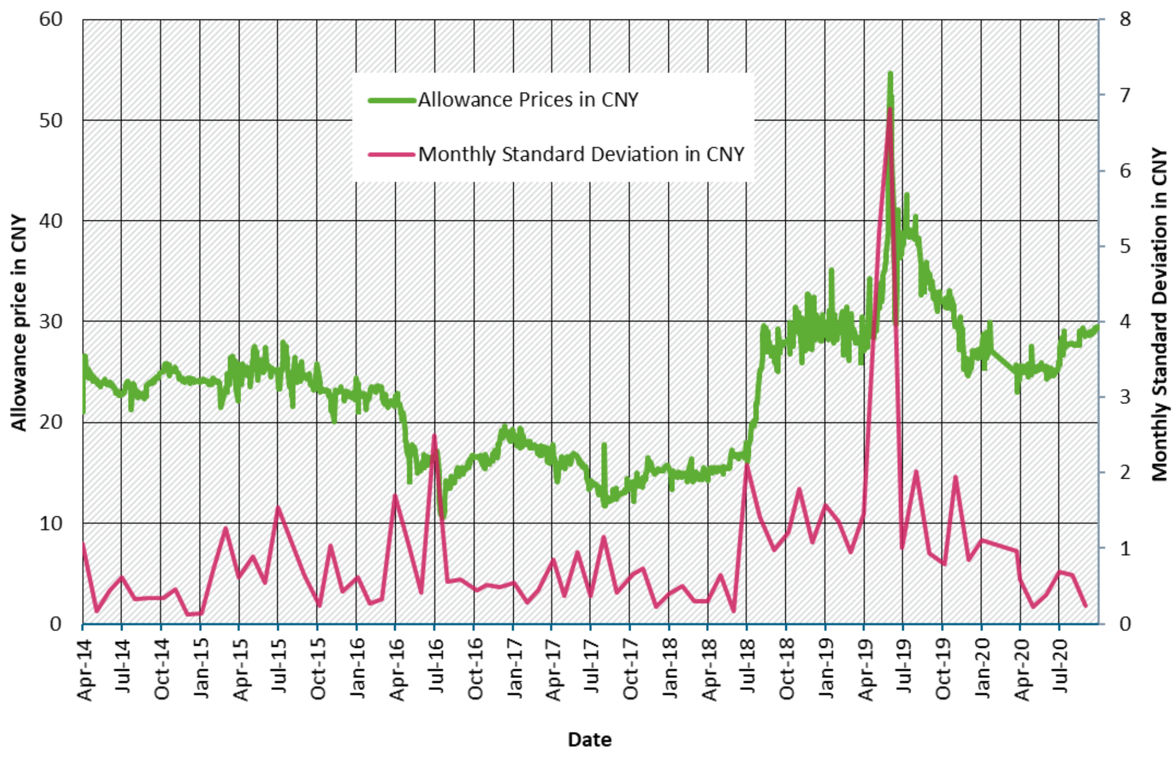
Source: Annual Report of China Carbon Market 2019; Hubei Emissions Exchange; and Forecast and Outlook of China's Carbon Market in 2017. Due to the limited publicity, some information from the early years is missing from publicly available sources.

Hubei's allowance price was relatively stable during the initial two years of the pilot scheme, before prices reached a low in July 2016, which triggered government intervention to abruptly suspend trading of allowances in order to prevent the price from plummeting further (see figure 1). For some commentators, the relatively stable price reflects both positive and defective parts of the pilot scheme. On the one hand, the trading volume is tepid as compared to the size of the cap, meaning that liable entities tend to hold on to their allowances and therefore the number of allowances in circulation is small. In general, the demand for allowances was low because the supply was sufficient, meaning that the cap-setting was rather loose and symbolic rather than stringent. The loose cap put very little pressure on the regulated entities and did not provide strong incentives for low-carbon investments or purchasing of allowances. The stable price during the early stages of the pilot program is attributed to the sufficient supply of allowances and the relatively evenly distributed trading activities across the trading period from 2014-2016. A previous study suggests that among the seven pilots, Hubei's ETS trading has the lowest level of concentration throughout the year, which is shown by the consistency of trading across the compliance period (Beijing Institute of Technology, 2017). For other ETS pilots, trading of allowances often scatters across the year and certain days have witnessed much more trading activities, leading to volatility of the allowance price (ibid).

[13] The 2019 data is sourced from Tanjiaoyi Website ("Annual Report of China Carbon Market 2019"),; The information in 2017 and 2018 is sourced from the Hubei Emissions Exchange.

The significant drop in price in July 2016 was mainly caused by two factors. Firstly, sufficient supply of allowances enabled more liable entities to sell allowances on the market. As the deadline of compliance approached and the rules on banking of allowances in Hubei incentivised liable entities to sell unused allowances, the market was suddenly flooded with sellers while the demand for allowances was low, leading to a price drop. Secondly, the national policy on reducing overcapacity in the energy intensive industry, which has been implemented in selected industrial sectors since 2016, also impacts Hubei's ETS pilot by reducing the demand for allowances. From 2017 onwards however, as the actions towards capacity reduction progressed and a number of small enterprises were eliminated, the production of large enterprises less affected by the capacity elimination increased, giving rise to higher demand for allowances before the end of the compliance period in 2018. An analysis reveals that the rise of production by large industry actors, together with demand of investors and limited supply of CCERs, means that the demand for allowances in Hubei in the compliance period of 2018-2019 could be as much as 6-7 million tons (Tanjiaoyi Website, 2018). The higher demand for allowances from large industry players caused prices to increase in 2018 and eventually spike in early 2019.

Figure 1: Allowance Price in Hubei's ETS Pilot Scheme



Source: http://k.tanjiaoyi.com/ (until September 2020).

On the other hand, the interviewees commented that the price regulation mechanisms in Hubei are clearly designed and market confidence is helped to maintain by the fact that government intervention will be triggered under the prescribed rules (however, as discussed in section 2.1.5, government intervention did not follow the prescribed rules when the allowance price plummeted in mid-2016). According to one interviewee, despite the reduction of the emissions cap in 2015, the percentage of initial allocation against the overall cap was raised from 70% in 2014 to 87% in 2015, leading to an oversupply of allowances that then sent the price down before the end of the compliance period in 2016 (see figure 1).

3.1 Volatility

Allowance prices in Hubei have not demonstrated excessive volatility. Since the inception of the system, Hubei allowances have averaged 23 CNY (2.91 EUR) and have ranged from a minimum of 10 CNY (1.27 EUR) in July 2016 to a maximum of 55 CNY (6.96 EUR) in July 2019. The allowance price has also not experienced high levels of intramonth volatility. The average monthly standard deviation between 2014 and 2020 was 0.91 with a maximum of 6.8. Higher periods of monthly volatility are associated with price drops or spikes, rather than increased short term variation around the mean price.

Several elements of system design may have contributed to low levels of price volatility. Firstly, the process of ex-post adjustment through the allocation mechanism allows the system to respond to variations in emissions allowance demand. With the exception of 2019, these adjustments on the supply side reduce the responsiveness of the allowance price to shifts in demand. Secondly, as discussed in the section on banking and borrowing, entities must trade allowances before they can be banked and carried over to the next compliance period. It is possible that this regulation has encouraged liquidity and hence stabilized allowance prices. Finally, Hubei has developed relatively complete market oversight rules and market stability mechanisms which, when enforced, restrict the volatility of the allowance price. Indeed, the existence of these rules will impact price expectations from participants and may have contributed to reducing volatility. In practice, the government intervened in the market in July 2016 to stop the allowance price from falling by abruptly suspending the trade of allowances. However, in doing so, they did not follow the rules for market stabilization mechanisms. According to interviewees, failing to follow the prescribed rules may have detracted from the predictability of the price signal.

On the demand side, Hubei has expanded the coverage of its ETS since its inception. The number of regulated entities increased from 138 when the pilot first commenced operation in 2014 to 338 in 2019. In theory, the wider scope could have contributed to increased liquidity and hence lower price volatility. In practice, we do not see a relationship between broadening scope and price volatility. In fact, the number of transactions has actually decreased over the same period, partly because liable entities' primary concern is to have sufficient allowances for compliance. With the *ex-post* mechanism in place and the uncertainties of their production levels, liable entities tend to hold on to their allowances and refrain from participating in trading allowances.

Finally, Hubei is an open market, which enables a wide range of stakeholders and investors to trade allowances. However, little information was obtained or is publicly available as to how many traders/investors participated in trading in Hubei.

3.2 Reflection of marginal abatement cost (MAC)

In theory, a high quality or undistorted allowance price equals the marginal abatement cost (MAC) of all market participants. In practice, there are a number of elements of the Hubei ETS design that might result in a distorted price signal. Most prominently, the allocation method might distort incentives for mitigation. Hubei has adopted the *ex-post* adjustment mechanism to alter the number of allowances liable entities can receive. The objective is to avoid a negative impact of carbon trading on economic development by reducing the risk of under- or oversupply (Brookings, 2015). In addition to macroeconomic reasons, adjustments were considered necessary to overcome the obstacle of data inaccuracy and the reluctance of key emitters to participate in the ETS (Sun & Wang, 2017). In Hubei, the implementation of measures to address overcapacity in the energy intensive industry requires a certain degree of flexibility to mitigate the impact on the ETS of emission reductions resulting from non-ETS measures (Qi et al., 2014).

Adjusting allocations on the basis of verified emissions could disrupt the reflection of the MAC. The downwards adjustment of allowances can discourage the regulated entities to implement ambitious emission reduction measures and thus contradicts the low-carbon investment signal that the ETS is supposed to send. Indeed, the operator of an industrial facility has no interest in reducing emissions if this triggers a downwards revision of its allowances. Furthermore, according to several interviewees, the problem with the ex-post adjustment of allowances (both downwards and upwards) in Hubei is that such a mechanism functions as a subsidy, which reduces the compliance cost and thus MAC for liable entities. However, as argued in the literature, this mechanism exposes investors to a considerable degree of uncertainty (Wang et al., 2019). The complex balance between emission reduction and economic development comes at the expense of predictability and effectiveness of the carbon price signal (Boute & Zhang, 2019; Brookings, 2015).

The allowance price may also be distorted from the MAC due to the implementation of the transaction rules. Hubei is governed by carefully designed transaction rules. However, Hubei faces restrictions on the operation of the exchange, resulting from the decision of the State Council not to authorize the Emissions Exchanges to operate on a similar basis to the stock exchanges (State Council, 2012). This results in a distorted carbon price signal because the Emissions Exchanges are not allowed to conduct instant transactions and clearance, thus making the price unpredictable. Delays in transaction closures have created concerns for compliance buyers that feel they cannot rely on the price signal to make sale-purchase decisions. As a result, compliance buyers tend to hold on to their allowances and avoid trading them unless they are confident that they hold what they need for compliance in the relevant compliance period.

3.3 Long-term predictability

Hubei's system design contains elements that both support and detract from long-term price predictability.

The nature of the pilot schemes in relation to the National Chinese ETS renders their long-term fate uncertain. In this context, regulators have refrained from setting long-term targets which makes a longer-term assessment of allowance scarcity difficult. With regards to ex-post adjustment in the allocation method, significant discretion is enjoyed by regulators when determining how many additional allowances to bring to the market. An interviewee explicitly points out that calculation of the adjustment factor is complex and not transparent, resulting in uncertainty for market participants.

Hubei also operates with provisions for market stability that might be expected to improve the long-term predictability of the price. However, the market stabilisation mechanism has never been triggered because the price floor or ceiling is not a fixed number and it is determined based on rules that are referenced to the daily allowances price.. According to the interviewees, neither mechanism has been implemented in practice. The impact of the mechanism on the predictability of the allowance price is difficult to assess. On the one hand, the mechanism plays a very important symbolic role to ensure market confidence and thus contribute to the stability of allowance prices. On the other hand, implementation of the mechanism relies on the discretion of the local authority which may act outside of the guidance of the 'Independent Advisory Committee'. Interviews highlighted that this exposes the market to regulatory uncertainty, a sentiment that has also been raised in the literature (Boute & Zhang, 2019; Tao & Mah, 2009).

Finally, the undefined legal and fiscal nature of allowances in China has generated uncertainties about whether financial market regulation would apply to allowance trading. The implications from the uncertainties are two-fold. On the one hand, it is still largely uncertain whether the allowances will be treated as commodity or financial products. Even though Hubei is trying to experiment with trading of allowance futures, the trading volume is small and market participants are still doubtful about the legality of trading allowance futures, largely due to the lack of definition of the legal and fiscal nature of allowances by the national level legislation/regulation. As discussed above, many scholars in China believe that emissions allowances are quasi-property rights. However, such a definition faces challenges to respond to the need of liable entities to mitigate price risks. With the spot transaction as the only means of transaction (without derivatives), the regulated entities lack risk hedging tools and cannot manage the price risk arising from their carbon assets and emission reductions. As a result, as the experiences in Hubei suggest, the level of predictability of the carbon price emanated from spot transactions is highly uncertain.

3.4 Environmental effectiveness of ETS

The environmental effectiveness of the Hubei pilot is difficult to determine, given the lack of data surrounding verified emissions and the inherent difficulty in attributing changes to emissions to a single policy instrument. However, several design issues point to a focus on flexibility for covered entities rather than a strict environmental target.

Setting long-term targets is difficult given uncertainty surrounding the future of the pilots once the national ETS system begins in the coming years. However, there is also a degree of uncertainty surrounding the allowance cap in the short term. The total size of the cap is fixed, but the composition of the cap remains unknown (i.e. the amount of allowances that are initially allocated to regulated entities and the total amount of allowances reserved for new entrants).

In addition, the ex-post adjustment mechanism in Hubei alters the number of allowances liable entities can receive. While this adjustment should be guided by an allocation formula, one interview explicitly points out that the regulator still enjoys discretionary power to adjust the amount of supply through the complex calculation process using the market adjustment factor. A tendency to protect local industry is more likely to put more allowances in circulation and therefore send the allowance price down at the expense of the environmental effectiveness.

In practice, an interviewee confirmed that the ex-post adjustment tends to add more allowances in circulation. The Hubei ETS regulated entities that increased production during the compliance period to benefit from additional allowances to cover their increased emissions (Qi et al., 2014). For example in 2015, 6 out of the 26 liable entities in the power generation required additional allowances (allowances will be provided to installations if their verified emissions are 20% above or 200,000 tons more than the number of allowances initially allocated to them; and vice versa) and only 2 entities were subject to allowances being taken away from them. Upwards adjustment protects the operators of industry facilities from increasing compliance cost but at the expense of a fixed, transparent emissions limit (cap) and quality carbon price signal that is fundamental for an ETS to function.

4 Design and Regulation of the Shenzhen ETS Pilot

Launched in June 2013, the pilot ETS in Shenzhen was the first pilot program under China's ETS experimentation scheme. The ETS pilot covers around 40% of Shenzhen's total emissions, with liable entities from both the upstream (direct emissions) and downstream sectors (indirect emissions) (ICAP, 2020). All liable entities, those with CO_2 emissions of more than 3,000 tons per year in any year and large-scale public buildings and office buildings with a construction area of more than 10,000 square meters, are required to surrender one allowance or an eligible offset credit within a fixed limit for each ton of their verified GHG emissions before the end of June of each year. Shenzhen's ETS pilot has a unique design of covering indirect emissions. These are emissions that are generated indirectly by the consumption of electricity produced by burning coal or other types of fossil fuels in another facility. Another unique feature of Shenzhen's pilot ETS is the allocation method to liable entities from the manufacturing sector. As elaborated further in section 4.1.2, the method of competitive bidding for free allowances has been adopted in Shenzhen to overcome the challenges of information asymmetry and wide coverage of Shenzhen's pilot program of entities from the manufacturing sector. The coverage presents a complex combination of upstream and downstream entities with a wide range of different products, production technologies, processes, and energy mix.

Table 6 gives an overview of supply and demand side design features in the Hubei's pilot ETS program. In the following chapter, we describe the individual design features in more detail. In chapter 5, we reflect on the design features' impact on the environmental effectiveness of the system and the quality of the allowance price signal along three dimensions: (1) price volatility, (2) reflection of the marginal abatement cost (MAC), (3) long-term predictability and (4) environmental effectiveness.

Table 5: Overview Supply and Demand Side Design Features in Shenzhen's Pilot Program

Feature	Pilot ETS Design in Shenzhen	Comment
Allowance Cap	Intensity	Intensity reduction targets of 2%, 2% and 25% to the power, water supply and manufacturing sectors respectively during 2013-2015 Annual cap from 2013 to 2015 is estimated at 33.2 Mt, 33.78 Mt, and 34.78 Mt respectively
Mid-term Target Long-term Target	2030 target at the national level: adopted 2060 target at the national level: recently announced	2030: reducing carbon emissions intensity by 60-65% from the 2005 level 2060 target to achieve GHG neutrality As Shenzhen's intensity target is assigned by provincial government of Guangdong, the pilot ETS in Shenzhen contains neither a short-term target nor a long-term target
Primary Allocation (in electricity sector)	Initial allocation determined every three years based on benchmark and expected output	Prior to 20 May each year, actual amount of allowances determined based on reporting of emissions and sectoral intensity target Discretion held by Shenzhen DRC to supplement or cancel allowances that have been handed out during the initial round of allocation

Feature	Pilot ETS Design in Shenzhen	Comment
Banking Borrowing	Allowed with restrictions Not allowed	Banking of unused allowances for future compliance periods, subject to a 3-year period but can be extended upon approval by the relevant authority
Offsets	Up to 10% of entity's obligation	Excluding local CCERs that come from the sectors that are covered by the cap, even if they are produced in surplus of the requirements
Market Stability Mechanism	Price bounds and allowance reserve	When oversupply of allowance, buying back up to 10% of allowances in circulation through negotiation; In case of allowance scarcity, selling allowances at fixed price and these allowances are not eligible for trading; Price bounds are not specified.
Voluntary Cancellation	Allowed	
Coverage	~40% of municipal GHG emissions (2015)	Only CO_2.
Market participation	Open system	

4.1 Allowance supply

Compared to Hubei, Shenzhen has taken a different approach to set up an intensity-based cap on emissions (Shenzhen Government, 2014a). As discussed below, Shenzhen's approach of cap setting follows the intensity target that is decomposed and assigned by the Guangdong Provincial Government.

4.1.1 Allowance cap and long-term targets

Shenzhen's intensity target is allocated through a top-down approach. The State Council allocates the targets to provincial governments and the provincial target is then broken down to municipal governments within each province. Shenzhen's latest target is assigned by Guangdong Provincial Government in accordance with the Implementation Plan for Controlling Greenhouse Gas Emissions in the 13th Five-Year Period of Guangdong Province (Guangdong Government, 2017, ch. 4, section 1). The target is to reduce carbon emissions per unit GDP by 19.3% by 2020 (ibid). Given the long-term national target to reduce carbon emissions intensity by 60-65% by 2030 from the 2005 level, the Shenzhen Municipal Government is expected to deliver some further reductions of its carbon emissions intensity in the coming years.

Table 6: Shenzhen's Targets to Reduce Carbon Emissions Intensity during 12th and 13th Five-Year Plan Period

	12th Five-Year Plan Period (2011-2015)	13th Five-Year Plan Period (2016-2020)
Shenzhen's Intensity Target (reduction of carbon emissions per unit GDP)	21%	19.3%

Considering the dynamic relation between economic growth, structural transition and the policy objective to control emissions, the Shenzhen DRC has opted for an intensity-based cap so as to address the uncertainty in output levels due to Shenzhen's rapid growth and accelerated structural adjustment (Shenzhen Emissions Exchange, 2013). Shenzhen's approach is in line with the national intensity target, which is decomposed and assigned to provinces and municipalities every 5 years. The intensity reduction target in Shenzhen therefore takes account of the assigned target by Guangdong province.

For example, during the first phase of Shenzhen's pilot program (2013-2015), the target, assigned to Shenzhen by the Guangdong Provincial Government, was to reduce carbon emissions intensity by 21% during the 12th Five-year period (2011-2015) (ibid). Shenzhen's carbon emissions are mainly generated from industry, transportation, service and residential sectors. With the improvement of living standards, demand for fuel from transportation and service industries and residential sector are expected to increase. Therefore, in order to meet the national carbon intensity target during the 12th Five-year period, the industrial sector in Shenzhen needs to undertake heavier tasks of energy conservation and emission reduction, meaning that the reduction of carbon intensity by Shenzhen's industrial sector must exceed 21%. Shenzhen's industrial sector includes water supply, power generation, gas companies and industrial manufacturing.

As articulated by the interviewees, Shenzhen's carbon emissions portfolio and the emissions reduction potential of different sectors means that, in order to achieve the carbon intensity reduction target of 21%, Shenzhen's manufacturing industry must achieve more than 25% carbon intensity reduction during the initial phrase of Shenzhen's ETS pilot (2013-2015). Therefore, Shenzhen's pilot program set intensity reduction targets of 2%, 2% and 25% to the power, water supply and manufacturing sectors respectively during this period (Jiang et al., 2014). For power and water supply sectors, the intensity is determined by the amount of CO_2 emitted per unit electricity generated or water supplied (see e.g., Shenzhen DRC, 2016a, part 2). And the intensity-based cap for power and water suppliers is calculated based on intensity benchmarks, combined with the projected level of output (ibid). The manufacturing sector is subject to a sector cap that is established by intensity benchmarks and projected sector production (ibid). Practically, however, it is not possible to determine uniform intensity benchmarks in the manufacturing sector due to the different carbon footprint of different industrial products. To alleviate this problem, the amount of CO_2 emitted per unit industrial added value is used to establish intensity benchmarks, and it is combined with the projected sector output to determine the sector cap (Shenzhen Government, 2014a, art. 19, para. 2).

Shenzhen's ETS regulator – the Shenzhen DRC does not publish information regarding the size of the cap or the long-term intensity target, the latter of which is dependent on the national target and its allocation to lower level government through the top-down approach. Several interviewees suggest that during the initial phrase (2013-15) of Shenzhen's ETS pilot, the total amount of eligible permits is estimated to be around 118 million tons, including 107 million tons of allowances and 11 million tons of CCERs. Among the 107 million tons of allowances, the annual amount from 2013 to 2015 is 33.2 million tons, 33.78 million tons, and 34.78 million tons respectively.

The coverage of the ETS pilot scheme accounts for around 40% of Shenzhen's total emissions.

4.1.2 Initial allocation of allowances

There are two allocation methods under Shenzhen's ETS pilot: free allocation and allocation through auctioning and sale at fixed price (ibid, art. 16). Allowances allocated free of charge include pre-allocated allowances, allowances reserved for new entrants, and allowances used for adjustment. The alternative method of allocation through auctioning and sale at fixed price plays a much smaller role under Shenzhen's ETS pilot.

In principle, the initial round of allowances allocation is determined every three years (ibid, art. 17, para. 4).[14] Considering the principles of fairness and equity, as well as the different carbon emission portfolios of liable entities, Shenzhen uses the benchmark method to carry out initial allowance allocation (ibid, art. 17).

For sectors that produce a single product, including production and supply of electricity, heat, water, and gas, the number of pre-allocated allowances is determined based on factors including the benchmark of carbon emission intensity of the industry in which the enterprise is located and the individual entity's expected output, namely (ibid):

*Pre-allocated allowances = Benchmark of carbon intensity target of the industry in which the company is located * Expected output*

For sectors that produce multiple types of products, industrial added value is adopted as a unified measurement to determine the amount of pre-allocated allowances (ibid). These sectors include the manufacturing enterprises that account for most of Shenzhen's industrial enterprises, such as communications equipment manufacturing, machinery equipment manufacturing, plastic production, etc. Due to the large variety of products and the difficulty to determine benchmarks for each type of product, the calculation for initial permit allowance is through the following method:

*Pre-allocated allowances = Carbon intensity target of individual entity * Expected industrial added value of individual entity*

The empirical information from the interviews suggest that the cumulative number of pre-allocated allowances for 635 companies during the initial stage of the ETS pilot (2013-2015) was 101 million tons. Compared to the level of carbon emissions in 2010, the total number of allowances allocated in 2015 increased by 7.8%. During the same period, Shenzhen's carbon intensity decreased by 36.8%, and the average annual carbon intensity reduction rate was 8.8%. Among them, the carbon intensity of manufacturing enterprises decreased by 37.81%, and the carbon intensity of single product industries such as water and electricity supply decreased by 5.43%. The average carbon intensity reduction rate across the liable entities is 30%, which exceeds the 21% reduction target of Shenzhen's carbon intensity during the 12th Five-year Plan period.

Allowances Allocation through Competitive Bidding in the Manufacturing Sector

Allocating allowances in the manufacturing sector in Shenzhen brings several challenges. First, indirect emissions (through importing electricity from outside of Shenzhen) are the main source of emissions by Shenzhen's manufacturing enterprises. Second, due to the relatively large number of regulated entities, information is incomplete and very little is known regarding the emission levels and carbon intensity of various enterprises in the manufacturing sector during the design phase. Shenzhen's ETS pilot covers 26 industrial sectors and hundreds of enterprises,

[14] The latest allocation rules were announced in 2016 which apply to the initial allocation in the compliance year of 2017, 2018 and 2019 respectively.

with a complex combination of upstream and downstream entities and a wide range of different products, production technologies, processes, and energy mix. Third, neither the regulator nor the enterprises have a comprehensive understanding or knowledge about the distribution of carbon intensity among the manufacturing enterprises in Shenzhen. The government knows very little about the internal operation of the regulated enterprises and the enterprises have no knowledge about their carbon intensity level or their position across the carbon intensity spectrum in a given sector.

In view of the above reasons, the core design of allowance allocation in Shenzhen's manufacturing sector is to fully allow, encourage and guide enterprises to participate in the discussion and information exchange related to allowance allocation. The aim is to facilitate enterprises' proactive strategies on market equilibrium in the process of information exchange. Therefore, allocation to liable entities under Shenzhen's ETS is by a method of competitive bidding for free allowances (ibid, art. 17, para. 2). The competitive bidding shifts the focus of allocation from a government-led approach to a game between manufacturers.

In order to determine the carbon intensity target for each manufacturing enterprise, the competitive bidding method divides enterprises into various groups based on their sub-industry types, product types, and scales. The regulator sets the upper limit of the number of allowances for liable entities in different groups according to the sub-industry's carbon intensity targets. It then requires entities in the same group to report information regarding the total amount of carbon emissions and the expected industrial added value for the specified period through the designated software. The initial allocation is carried out by the software to assign allowances to the enterprises. Because the sector cap for manufacturers is set in the initial round of allocation, liable entities compete with each other in finite repeated rounds for free allowances (ibid). Each liable entity makes a decision about the bidding offer based on its historical emissions, the average level of emissions in the given sector, reduction commitments, and its comparative advantage over other enterprises. In each round of the game, outcomes are notified to all entities in the group in order to disseminate information about the allocation. An enterprise satisfied with the allocation result may choose to accept and leave the game. Entities that are dissatisfied shall continue to compete in the game in the next round. Since the cap is given, allowances accepted by entities will be deducted from the sector cap and the number of allowances will reduce with the progressive rounds of the game. In the final round, firms that are still in the game can only receive allowances from the remaining balance (ibid). The carbon intensity target for each of the enterprises is then calculated based on the carbon emissions and the industrial added value accepted by an enterprise in the competitive bidding process.

Allowance Adjustment Mechanism

Prior to 20 May each year, Shenzhen DRC determines the actual amount of allowances for each liable entity based on the reporting of emissions, industrial added value (if applicable) and the sector's intensity target (ibid, art. 19). The general approach to determine the actual amount of allowances is through the following method:

*Actual amount of allowances = Real output of liable entity * Carbon intensity target*

The Shenzhen DRC has the statutory authority to supplement or cancel allowances that have been handed out during the initial round of allocation, taking into account the intensity target applicable to the sector and the real output by the liable entity (ibid, art. 19, para. 1). In order to balance the demand and supply, the general principle is that the number of supplementary allowances must be lower than the number of allowances that are subject to cancellation (ibid, art. 19, para. 3).

Allocation through Auctioning and Sale at Fixed Price

In addition to free allocation, auctioning is included in the regulation as an alternative allocation method under Shenzhen's ETS pilot scheme. In theory, "[t]he number of allowances sold by auction shall be no less than 3% of the total annual allowances. The municipal government can gradually increase the proportion of allowances for auctions according to the development of the carbon emissions trading market." (ibid, art. 20, para. 1-2). The first (and the only) auction was organised in 2014 with a total of 200,000 tons of the 2013 allowances (SZA-2013) up for auctioning. At the end of the auction, 74,974 tons were successfully sold at a base price of 35.43 CNY (4.48 EUR).

The interviewees suggest that a total of 113 liable entities registered for bidding in this auction and 94 entities participated in the bidding. The highest bid price was 80 CNY (10.12 EUR) and the lowest bid price was 35.43 CNY (4.48 EUR). Because the number of bids is less than the total number of allowances for auctioning, the lowest bid price was accepted in accordance with the auction rules. In fact, most bidding prices were higher than the auction reserve price, with an average bid price of nearly 50 CNY (6.33 EUR). The auction in Shenzhen was organised mainly to attract liable entities that face a shortage of allowances to participate. It is said that there were more than 200 liable entities that met this condition, but the number of registered bids and actual bids was significantly smaller.

Allocation through selling at a fixed price, which is determined by the Shenzhen DRC is designed as part of the price regulation mechanism. In order to stabilise the allowance price, 2% of the allowances is reserved to be sold at a fixed price when the allowance price is considered too high (details discussed in below section 4.1.5 pricing regulation).

4.1.3 Banking and borrowing

Under Shenzhen's ETS pilot, while borrowing is not allowed, liable entities can bank unused allowances for future compliance periods (ibid, art. 27). The eligibility for banking is generally subject to a 3-year period but can be extended upon approval by the relevant authority ("Shenzhen Emissions Exchange FAQ", 2013).

4.1.4 Provisions for additional allowances supply

The Shenzhen ETS allows covered entities to meet no more than 10% of their obligations by surrendering CCERs. One unit of CCER is equivalent to one unit of emission allowance (Shenzhen Government, 2014a). However, the ETS regulation in Shenzhen explicitly excludes local CCERs that come from the sectors that are covered by the cap, even if they are produced in surplus of the requirements (ibid).

4.1.5 Market stability mechanisms

To stabilise the allowances price, Shenzhen's pilot program has established an allowances reserve dedicated to price stabilisation (ibid, art. 15). The reserve contains allowances that are put aside by the Shenzhen DRC, allowances for new entrants and the allowances that are bought back from the market (ibid, art. 21, para. 1). The Shenzhen DRC, as the administering authority of the reserve, has the statutory authority to enforce the stipulated measures with respect to price regulation (ibid, art. 4). Because the aggregate allowance supply in Shenzhen is decided by real output and a fixed intensity target, whereas demand is determined by uncertain marginal abatement cost, Shenzhen faces a greater challenge of guiding market expectation effectively. To address the potential danger of putting more allowances in circulation, the regulators in Shenzhen explicitly require that allowances from the reserve are sold at a fixed price determined by the DRC for compliance purposes only, and they are not eligible for trading (ibid, art. 21, para. 2). In case of oversupply of allowances, the Shenzhen DRC is authorised to buy back no more than 10% of the total number of allowances from the market through negotiation (ibid, art. 22). Despite the significant price fluctuation at the early stage of the ETS pilot, the price stabilisation mechanism in Shenzhen has yet to be tested in practice. From a regulatory point of view, however, the mechanism remains broadly formulated. There is a need for clarification as to when and how the mechanism can be activated and enforced.

4.1.6 Voluntary cancellation of allowances

Shenzhen's ETS pilot allows voluntary cancellation of allowances but neither individuals nor environmental groups have exercised voluntary cancellation in practice.

4.2 Demand

4.2.1 Coverage

Like Hubei, Shenzhen's ETS pilot scheme covers only CO_2 (ibid, art. 2). The Shenzhen ETS covers enterprises with CO_2 emissions of more than 3,000 tons per year in any year and large-scale public buildings and office buildings with a construction area of more than 10,000 square meters[15]. Altogether, 26 industrial sectors and hundreds of enterprises are covered, with a complex combination of upstream and downstream entities and a wide range of different products, production technologies, processes, and energy mix. Shenzhen relies on importing electricity from other parts of Guangdong and its power generation assets are dominated by gas-fired units. Among the 8 liable entities in the power sector, 7 of them operate gas-fired units and only one entity has coal-fired generation assets. As the first pilot program in operation, Shenzhen's ETS pilot has a unique design of covering indirect emissions whereby emissions are generated indirectly by the consumption of electricity produced by burning coal or other types of fossil fuels in another facility. As discussed below in section 6, Shenzhen relies largely on imported electricity from other parts of Guangdong Province to meet its demand, therefore contributing to the high operating hours of coal-fired generators in other parts of Guangdong. Due to the limited pass through in electricity pricing, covering large buildings by the ETS provides a signal for behaviour changes by end consumers to increase energy efficiency (Jiang et al., 2014).

The interviewees suggest that Shenzhen's ETS coverage is underpinned by two main considerations. First, Among the liable entities, utilities in the power, gas and water supply sector only represent a very small percentage of ETS installations in Shenzhen. Shenzhen's industrial sector has the highest total energy consumption among all sectors, accounting for about 33% of the total energy consumption in Shenzhen. The energy consumption levels and the marginal abatement costs to reduce emissions for different sectors vary widely, which allows the ETS to function in order to achieve the lowest marginal abatement cost. Second, the energy consumption of buildings accounts for about 23% of the total energy consumption. The electric load of buildings accounts for more than 43% of Shenzhen's total electrical load, and the energy consumption per unit area of buildings in Shenzhen is more than three times of that in developed countries. In addition, due to the increase of new buildings and the large number of

[15] In addition, the Shenzhen DRC may gradually include in the ETS entities with CO_2 emissions of more than 1,000 tons but less than 3,000 tons in any year (ibid, art. 13). These entities shall report their CO_2 emissions to the Shenzhen DRC every year and are subject to the same reporting requirements as prescribed for the other regulated ETS entities. Furthermore, the Shenzhen DRC can designate other entities to participate in the ETS (ibid, art. 11).

glass curtain walls and large windows, Shenzhen's building energy consumption is still on the rise.

4.2.2 Market participation

Shenzhen is one the first ETS pilot schemes to open its market to a wide range of participants. Third parties can voluntarily participate in the ETS pilot, with approval by the Shenzhen DRC. In 2014, the State Administration of Foreign Exchange officially approved the participation of foreign investors in Shenzhen's ETS pilot, making Shenzhen the first carbon market in the country to open to foreign investors (Shenzhen Emissions Exchange, 2014a).[16]

The Shenzhen ETS pilot is as such designed to be an open system which allows individuals and non-regulated entities, including individual and institutional investors to hold and trade allowances. As for trading, either transactions through bilateral basis or on Shenzhen Emissions Exchange is allowed. In practice, majority of the trading takes place on Shenzhen Emissions Exchange and trading through bilateral basis mainly involve trading of CCERs.

4.3 Transaction and market oversight rules

4.3.1 Legal nature of allowances

As for Hubei, the legal nature of allowances in the Shenzhen ETS remains unclear, in the absence of clarity on this issue at the national level. However, according to some interviewees, allowances in the Shenzhen ETS can be considered as a quasi-property right. This legal interpretation is based on the fact that the ETS regulation in Shenzhen allows regulated entities to transfer allowances for security only (as a pledge) and such transactions need to be filed with the allowances registry (Shenzhen Emissions Exchange, 2014b, art. 45).

4.3.2 Fiscal nature of allowances

Like in Hubei, the fiscal nature of allowances was left undefined in Shenzhen for many years due to the lack of official clarification by the central government agency on this issue. However, according to the Interim Regulations on Accounting Matters related to Carbon Emissions Trading, which was issued by the Ministry of Finance on 16 December 2019, allowances are now defined as intangible assets and there are some specific rules regarding accounting practices in the event of acquiring and selling allowances (Ministry of Finance, 2019).

With respect to accounting, the positions of allowances need to be documented as a separate group under intangible assets. Depending on the nature of allowances and their usage, various accounting requirements apply. Freely allocated allowances and such allowances as are used for compliance purposes or subject to voluntary cancellation are not required to be booked into the accounting sheet. Freely allocated allowances that are sold in the market are treated as non-operating income and must be booked as other receivables under bank deposit in the balance sheet. Acquired allowances from the market must be documented in the accounting sheet at the date of acquisition with the acquisition price. When the acquired allowances are used to fulfill the obligation of the liable entity, they are considered as non-operating expenditure and must be booked into the accounting sheet accordingly.

[16] To avoid confusion, this report uses Shenzhen Emissions Exchange to refer to the trading platform of emissions allowances under Shenzhen's ETS pilot scheme, instead of 'China Emissions Exchange' which is shown on its website.

4.3.3 Tax treatment rules for allowances trading

For many years during the ETS operation, there were no clear rules regarding tax treatment of revenue generated from selling allowances. Several interviewees comment that this is one of the significant barriers to increasing the trading volume of allowances. Liable entities are not willing to sell allowances because doing so generates complexity for accounting purposes. As discussed above, this issue has been properly addressed by the Interim Regulations on Accounting Matters related to Carbon Emissions Trading. This is an important step forward in preparation for the national ETS. Concerning tax treatment, both the VAT and corporate income tax may apply when the allowances are traded in the market. VAT is applicable to the transfer of allowances in the secondary market. Corporate income tax may also apply when the allowances are sold on the market.

4.3.4 Market places

The Shenzhen Emissions Exchange is the official trading platform where trading of allowances in Shenzhen takes place. Market participants include liable entities and institutional and individual investors, who can participate in the trading of allowances on the trading platform after registration with the Exchange. Transactions can be made through OTC trading, fixed pricing or bidding. Transactions through fixed pricing only take place when the government sells allowances if the price stabilization mechanism is triggered. Transactions can also happen when an auction is held and liable entities bid for additional allowances. However, trading of derivatives is not allowed.

4.3.5 Transparency regulation

According to the ETS regulation in Shenzhen, the competent department shall, in conjunction with other relevant departments, establish a public service platform to disclose the information related to the ETS pilot scheme in a timely manner (Shenzhen Government, 2014a). The Shenzhen Emissions Exchange shall establish an information disclosure system to announce transaction information such as daily trading volumes and the transaction amount on each trading day (ibid, art. 57). However, the transparency rules are not enforced to their full extent. For example, information with respect to the cap, allowances that are freely allocated, verified emissions and surrendered allowances are not publicly available.

4.3.6 Market abuse regulation

The *Specifications of Risk Control Management* instituted several mechanisms to deal with market abuse (Shenzhen Emissions Exchange, 2014c). These mechanisms include daily price fluctuation limits, restrictions on holding allowances acquired from transactions, reporting requirements imposed on parties involved in large volumes of allowances transactions, risk warnings and information disclosures.

First, for the daily price limit, the general rule is that price fluctuations of allowance transaction are capped at ±10% of the closing price of the previous trading day, meaning that the price of spot transaction on the trading day is evaluated against the closing price of spot transactions from the previous trading day (the benchmark) and the price must not be higher or lower than the benchmark ± 10% (ibid, art. 9). The price limit for bulk transactions is looser and is set at ± 30%.

Second, the provision regarding the restriction on holding allowances imposes slightly different rules on regulated ETS entities and other market participants. For regulated entities, except for pre-allocated allowances in the current compliance year and allowances carried forward from the previous year, the maximum number of allowances held by each regulated entity may not exceed 1.5 million tons (ibid, art. 14, para. 1). The maximum allowances held by other market participants may not exceed 2 million tons (ibid, art. 14, para. 2).

Third, the reporting obligation stipulates that market participants are required to report to the Exchange before the market closes on the next trading day if their holdings of allowances reach 80% of the maximum holding limit prescribed by the trading rules. The reporting obligation also applies to market participants if their holding of allowances increases or drops by 10% or more.

Finally, in the event of transactions involving price or settlement anomalies or other illegal activities, the Shenzhen Emissions Exchange may use risk warning measures when it deems necessary, such as oral or written warnings, and making risk warning announcements (ibid, art. 45 and 46). Meanwhile, the Exchange has also adopted an information disclosure system to publicise information of market participants who meet the reporting requirements prescribed by the rules, and to announce the top ten participants with the most allowances in their trading account on a monthly basis (ibid, art. 58).

Table 7: Annual Overview of Spot Transactions in Shenzhen's ETS Pilot Scheme

Type of allowance	Year	Average price (CNY)	Trading volume (Tons)	Turnover (CNY)
SZEA	2019	10.84 (1.37 EUR)	8,425,353	91,311,321 (11,555,658 EUR)
SZEA	2018	-	12,579,978	295,098,683 (37,345,190 EUR)
SZEA	2017	-	6,913,100	-
SZEA	2016	-	11,020,700	-
SZEA	2015	-	4,409,000	-
SZEA	2014	-	1,847,124	-

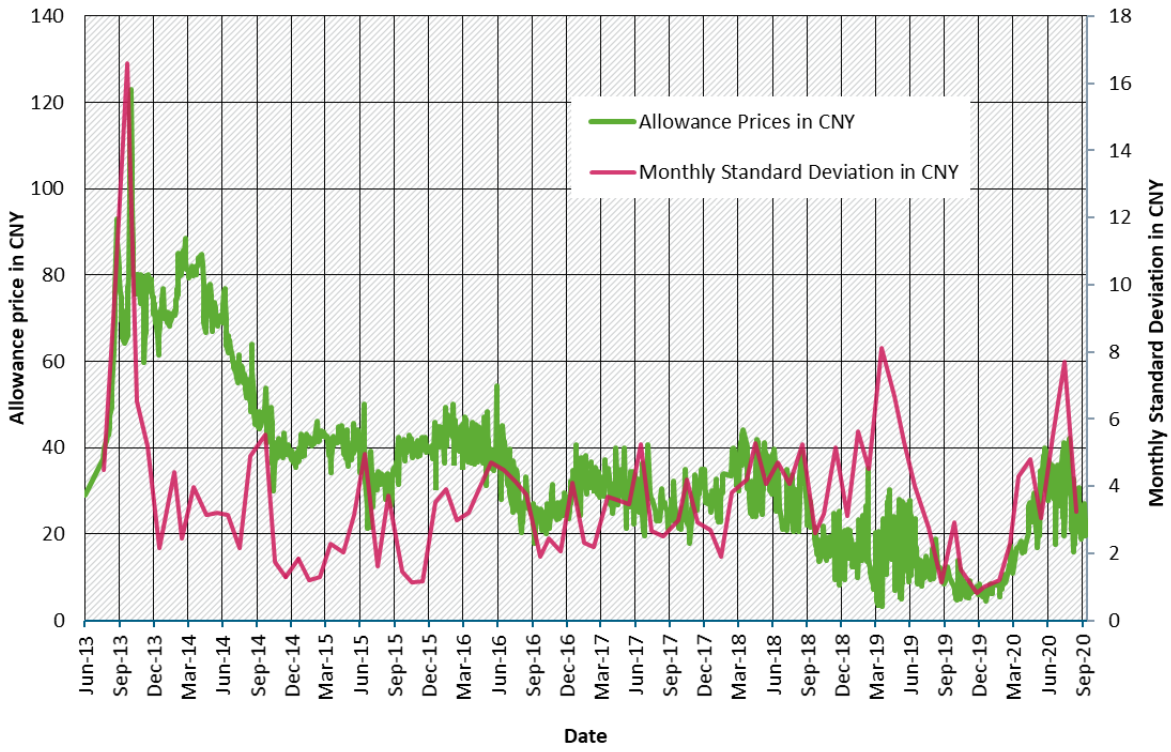
Source: Annual Report of China Carbon Market 2019; and Forecast and Outlook of China's Carbon Market in 2017. Due to the limited publicity, some information is missing from publicly available sources.

5 Assessing the ETS Design and the Quality of the Shenzhen Allowance Price

Although the Shenzhen ETS pilot is the smallest of the seven pilots, it has the most active and liquid allowance market in China. From 2013 to 2016, the allowances circulation rate in Shenzhen rose from 5.23%, 8.53%, 11.99% and to 16.10%, respectively, ranking first across the seven carbon markets in China for four consecutive years.

The cap of the Shenzhen ETS pilot accounted for around 2.5% of the total allowances of all seven ETS pilot schemes but it has achieved 15.5% of the total trading volume nationwide and 23.38% of the cumulative turnover of carbon markets in China from 2013-2016, due to the active trading activities. Starting from May 2015, the Shenzhen Emissions Exchange has published daily transaction volume and price, without providing an annual overview of the performance of the ETS pilot scheme.

Figure 2: Allowance Price in Shenzhen's ETS Pilot Scheme



Source: http://k.tanjiaoyi.com/ (until September 2020).

5.1 Volatility

Shenzhen's ETS pilot scheme experienced some significant price fluctuations at the early stage, reaching a historical high of 123 CNY (15.72 EUR) in the first compliance period ("Shenzhen Emissions Exchange, Development", 2014). However, despite the relatively high liquidity, the overall trend is that the carbon price in Shenzhen is collapsing and the average price in January 2020 is around 10 CNY (1.27 EUR) (Shenzhen Emissions Exchange, no date).

Despite the significant price fluctuation at the early stage, the overall allowance prices in Shenzhen have not demonstrated excessive volatility after the first compliance period. Since the inception of the system, allowances have averaged 36 CNY (4.60 EUR) and have ranged from a minimum of 3.30 CNY (0.42 EUR) in April 2019 and a maximum of 123.00 CNY (15.56 EUR) in October 2013. Since the start of the second compliance period, the allowances price has also not experienced high levels of intramonth volatility. The average monthly standard deviation between 2014 and 2019 was 3.64 CNY/t CO_2 with a maximum of 16.6. Higher periods of monthly volatility are associated with price drops or spikes, rather than with increased short-term variation around the mean price.

As with Hubei, the process of ex-post allocation adjustments may have contributed to the low levels of price volatility. On the demand side, Shenzhen has also expanded emissions coverage over the duration of the program. However, this has not had a notable impact on the systems price volatility.

Shenzhen is an open market which enables a wide range of stakeholders and investors to trade allowances. Individual investors and institutional investors accounted for around 9% and 2% respectively of the total transactions during the first compliance period (Shenzhen Emissions Exchange, 2014b). According to the interviewees, the diversification of investors increased liquidity but may have also contributed to a more volatile allowance price, due to the lack of enforcement of the price stabilisation and also the market monitoring mechanisms.

For Shenzhen, the intensity-based approach provides the most certainty and predictability to utilities in the power, gas and water supply sector. However, these sectors only represent a very small percentage of ETS installations in Shenzhen, and their impact on the allowance prices is thus minimal. For the majority of regulated ETS entities in Shenzhen (i.e. in the manufacturing sector), the problem of information asymmetry between regulators and ETS entities (discussed above in 4.1.2) creates large uncertainty regarding the supply of allowances. The lack of transparency increases the possibility of price volatility and unpredictability.

5.2 Reflection of marginal abatement cost (MAC)

The intensity-based cap adopted in Shenzhen and the complex regime governing allocation of allowances to the manufacturing sector requires the adjustment of allowances, taking into account the intensity target applicable to the sector and the real output by the liable entity. However, to the extent that additional allowance allocation is linked to recent emissions, there might be an incentive for entities to maintain emissions to ensure they do not receive lower allowance allocation and hence distort the allowance price signal.

Like in Hubei, adjustments were considered necessary under Shenzhen's ETS pilot to overcome the obstacle of data inaccuracy and the reluctance of key emitters to participate in the ETS. In Shenzhen, the direct link between emissions and allowance allocation could disrupt the reflection of the MAC. Despite the general rule that additional allowances available for the liable entities, in theory, shall be less than the total number of allowances being taken away from them, industrial sectors (other than water supply, power generation and gas supply) tend to maintain or increase activity levels and refrain from implementing ambitious emission reduction measures. The adjustment mechanism mostly affects Shenzhen's manufacturing sector because the carbon reduction potential of water supply, power generation and gas companies are less than the municipal reduction target, which is 21%. For example, Shenzhen relies on importing electricity from other parts of Guangdong and its power generation assets are dominated by gas-fired units. Among the 8 liable entities in the power sector, 7 of them operate gas-fired units and only one entity has coal-fired generation assets. The complex balance between emission reduction and economic development comes at the expense of predictability and effectiveness of the carbon price signal.

The challenges Hubei faces in terms of restrictions on the operation of the exchange are also present in Shenzhen. A distorted carbon price signal is caused by the Emissions Exchanges not being allowed to conduct instant transactions and clearance, thus making the price unpredictable. In addition, the lack of a long-term target also reduces the credibility of the ETS overall and therefore compromise the ability of the carbon price signal to reflect MAC.

5.3 Long-term predictability

The long-term predictability of the allowance price is impacted by the broader Chinese climate policy context as well as specific elements of ETS design. As discussed for Hubei, it is difficult for Shenzhen regulators to set a long-term allowance budget given the uncertainty surrounding the longevity of the system when the Chinese national ETS begins. Such regulatory uncertainty makes it difficult to form expectations around future scarcity and therefore price levels.

In terms of system design, the intensity and output-based allocation approach does not fully neutralise the need for government intervention in allocated allowances. Allowances are initially allocated for each compliance period based on the expected output of liable entities, and the government adds or deducts allowances as a function of the real output at the end of the compliance period. In order to create scarcity of supply, the regulator committed to not add more allowances than it deducts. At least in theory, the trend is thus towards the tightening of the market. However, calculating the allowances in Shenzhen involves more data and statistics which were not dealt with before by the regulator. What this means in practice is that the initial allocation tends to be generous, given the lack of experience and knowledge and the potential resistance from industrial participants if the allocation is too tight. This rather complex process can also make short-term allowance supply difficult to predict.

Shenzhen also has a market stability mechanism that while never implemented plays a very important symbolic role to ensure market confidence and thus contributes to the stability of allowance prices. That said, some interview participants expressed concern surrounding the discretionary nature by which the market stability measures are to be triggered. High price volatility in the early phases of the Shenzhen ETS pilot scheme and the subsequent halving of the carbon price (see Figure 2) did not trigger any regulatory intervention, despite surpassing triggers for intervention. As a consequence, the merely symbolic purpose of the price stability mechanism in Shenzhen does not prevent the allowance price from fluctuating and the lack of enforcement also provides little insight as to how to design a similar mechanism for the national ETS, in order to support a predictable and effective carbon price signal.

As with Hubei, the undefined legal and fiscal nature of allowances in Shenzhen has generated uncertainties about whether the financial market regulation would apply to allowances trading, detracting from price predictability.

5.4 Environmental effectiveness of ETS

As with Hubei, the environmental effectiveness of the Shenzhen Pilot is difficult to assess. While an intensity-based cap does not necessarily result in lower environmental effectiveness, translating the intensity-based cap to the amount of allowances that are available to the regulated entities poses some significant challenges and difficulties for implementation, particularly for the manufacturing sector. The carbon intensity reduction targets set by the Shenzhen Municipal Government for different sectors increase the complexity of designing the allowance allocation and increase the management cost for both the liable entities and government authorities. Because the calculation of the carbon intensity reduction target requires data of industrial added value from covered entities, the practice, however, reveals to be a challenging process due to the lack of importance attached to collecting such information and its calculation method. Standardising the process of reporting such information takes time and managing authorities of Shenzhen's ETS pilot have to work with data that is questionable in its accuracy to decide the amount of allowances that each liable entity is entitled to. The additional challenges arising from the data collection process may put the environmental effectiveness of Shenzhen's ETS pilot at risk.

Despite the difference of cap design methods in Hubei and Shenzhen, both methods are primarily designed to control rather than cap emissions. The primary consideration in this regard is not to reduce emissions but to increase efficiency and provide space for industrial expansion and thus economic growth (Qi et al., 2014; Jiang et al., 2014). As discussed in 5.3 above, data uncertainties combined with pressure from industrial facilities mean in practice that the initial allocation tends to be generous, detracting from the environmental effectiveness.

6 The Chinese Electricity Market

6.1 Market design and structure

6.1.1 Market design

The current structure of the Chinese electricity market is largely the result of the reform process initiated in the 1980s. The scholarly work on China's electricity sector reform is abundant and the general observation is that the governance framework governing China's electricity sector is fragmented. Electricity market regulation in China involves regulators at various levels of government. Besides, state-owned enterprises (SOEs) contribute to shaping the outcome of energy services through a decentralised approach (Lieberthal, 1992). In order to understand how the reform process has shaped China's electricity sector regulation, this section reviews the key areas of reform and highlights the changes that the reforms have made to the electricity market in China.

As observed by several commentators, many of the current investment challenges facing China's electricity industry have their historical roots in the highly inflexible planning system that characterised China's electricity system, in addition to the lack of systematic management and coordination between the different stakeholders (Kahrl et al., 2011; Ngan, 2010; Schuman & Lin, 2012). China's electricity sector has gone through several stages of reform. The initial reform in 1985 paved the way for the decentralisation of investment authority in China's power generation sector. This reform was carried out to fund the expansion of power generation capacity by opening investment financing to both domestic and foreign capital and by implementing differentiated on-grid electricity tariffs to mobilise financing (State Council, 1985). In order to fuel China's rapid economic transformation, the electricity industry in China witnessed an important increase in production and consumption of electric power from the 1980s.

In 1997, various reforms were adopted based on the international practice of corporatisation of the power industry. The objective was to gradually manage the electricity utilities independently of the government administrative structure (State Council, 1996).[17] To boost electricity supply, a constellation of local and provincial governmental actors was given powers regarding investments into the power generation sector. The broader involvement of institutional stakeholders at the provincial level diversified the regulatory landscape of China's power sector. As a legacy of these reforms, China's electricity sector is largely regulated at the provincial level. Provincial governments continue to manage key areas of electricity sector operation. This province-based electricity management system means that Hubei, as a province, and Shenzhen, which is part of Guangdong province, have different authorities over issues such as pricing and dispatch and the electricity sector reform process. That being said, the regulatory arrangements regarding pricing and dispatch that have been instituted over time during the reform of the electricity sector in China, as discussed below, also apply to Hubei and Guangdong (including Shenzhen).

The early reforms in the 1980s and 1990s were followed by further restructuring of the industry in 2002. The State Council of China, in the *Scheme of Reforming the Electric Power System*, dismantled the gigantic State Power Corporation and established 11 smaller companies (State

[17] State Power Corporation was founded in January 1997 by acquiring part of the functions of former Ministry of Electric Power Industry in the area of state-owned asset operation and enterprise management.

Council, 2002).[18] This scheme of reform was to break down the monopoly by separating generation and grid transmission, and aimed to introduce competitive bidding for power generation and dispatching (ibid). This reform process was successful in breaking down the vertical integration of power generation and transmission. It also introduced limited competition to China's power generation sector and accelerated the installed capacity of China's coal power generation with lower cost.[19] For example, from 2003 to 2010, China's "big five" power generation companies all tripled their respective installed capacity (Wang & Chan, 2012). However, in 2003 and 2004, the liberalisation reform process was interrupted in a context of electricity shortage (Ma, 2011).

In 2015, the government initiated new reform plans in order to improve the efficiency and flexibility of China's electricity sector, following the motto of "grasping the middle and liberalising both ends". This means the deregulation of the sale price of electricity for industrial users and the determination of separate transmission and distribution (T&D) tariffs (replacing the former "all-in" electricity tariffs) (State Council, 2015c).

Regulated electricity tariffs are now confined to the areas of residential use, the agricultural sector, key public utilities and public services (ibid, section 3, part 1). Revenues of grid companies come from collecting T&D tariffs, instead of the difference between on-grid tariffs and sale prices. This deregulation also allows and encourages direct trading, whereby industrial users and power generators can enter into contracts for the sale of electricity at a price that can be negotiated and agreed to by both parties (ibid, part 3(2)). If the reform policy is to be fully implemented, the 2015 reform can fundamentally change how the electricity sector is managed and operated in China. However, the progress of reform has been slow mainly because of the resistance from stakeholders with a vested interest in the status quo and the lack of legally binding force of the reform policy.

In China, regulated electricity tariffs and administrative dispatch present significant barriers for the implementation of regulatory instruments toward emissions reduction and thus reduced coal use. Despite recurrent reforms, China's electricity pricing (both the on-grid tariff and sale price) is still heavily regulated, whereas coal pricing has been increasingly liberalised. Coal power generators have long faced challenges to pass the rising cost of coal to end-users. When demand for coal starts to soar, the profitability of coal power generators is heavily curbed. This, however, does not necessarily translate into a diversion from coal, at least not in the short- to medium-term. Instead, grid dispatchers and the local governments behind them are interested in trying to keep coal-fired plant companies profitable by increasing operating hours (see e.g. the case of Hubei discussed below in section 6.1.2).

[18] These 11 smaller companies include two grid transmission companies (State Grid Corporation of China and China Southern Power Grid), five power generation companies (known as the "big five" including China Huaneng Group, China Datang Corporation, China Huadian Corporation, China Guodian Corporation and China Power Investment Corporation), and four power auxiliary companies (China Hydroelectric Engineering Consulting Group, China Power Engineering Consulting Group, China Water Resources and Hydropower Construction Group, China Gezhouba (Group) Corporation). In 2017, Guodian, one of the "big five" power generation company, and Shenhua, a leading coal company in China, were merged to create the China's largest energy company - China Energy Investment Corporation. See "State-owned Assets" (2017).

[19] The Annual Report from China Electricity Regulatory Commission in 2009 suggests that from 2001-2008 the average cost of constructing coal-fired plants in China has dropped for more than 20% ("Annual Report of Electricity Sector Supervision", 2009). The China Electricity Regulatory Commission was established as part of the reform process in 2002 to advance the reform in pricing. Its functions were later folded into the National Energy Administration in 2013.

Similarly, regulated electricity tariffs can undercut the effectiveness of an ETS that relies on the price signal to play its role, unless clear guidance is provided to the industry as to how the cost of carbon is integrated into electricity tariff methodologies.

Key players in the electricity market in Hubei and Shenzhen include regulators (including dispatch operator), major generators (mostly SOEs), power grid enterprises, end-users (such as industrial, residential, agriculture and public institutes, etc), and independent auxiliary service providers. The most recent electricity sector reform in 2015 enabled the establishment of electricity trading centres into the market.[20] This reform has also allowed electricity retailers to enter the market, besides producers, grid companies and consumers. In both Hubei and Guangdong, there are three types of electricity retail companies: the electricity retail companies established by the power grid enterprises, the retail companies established by private investors who have invested into the incremental distribution network and were granted distribution operating rights, and the independent electricity retail company.

Retail companies can sell electricity in multiple electric power service areas. Unbundling requirements apply. In particular, the retail companies established by the grid companies must be incorporated as independent legal entities. The objective of this unbundling requirement is to ensure that the retail companies – that operate on a competitive basis – are operated and regulated separately from the grid companies that continue to operate as natural monopolies. Similarly, for the electricity retail companies established by power generation enterprises, the electricity retail business must be separated from power generation activities.

6.1.2 Market structure and dynamics in Hubei and Shenzhen

Installed capacities and generation mix, Hubei

Compared to Shenzhen, electricity generation in Hubei is still constantly on the rise, due to the industrial expansion of the province. During the 12th Five-year Plan period (2011-2015), total generation capacity in Hubei increased by 5.5%, reaching a total of 641 million KW (see Table 10) (Hubei Government, 2017), and the trend of growth has been maintained during the 13th Five-year Plan period (2016-2020). By the end of 2019, the overall installed capacity in Hubei reached 786,200 MW and the generators across Hubei produced up to 297.29 million MWh electricity, which is around 61 million MWh more than the 2015 level (26% increase). Among the installed capacity, hydropower ranks first, followed by thermal power. Because the two major hydropower generators located in Hubei (Three Gorges Dam and Gezhouba Hydropower Plant) are subject to national dispatch and management (which often means that most of the electricity they produce is dispatched to other provinces), Hubei has to increasingly rely on coal-fired generation to meet its growing electricity demand. Based on the data from 2018, Hubei's coal-fired power generation still accounts for around 70% of its electricity production (Hubei DRC, 2019a). Electricity generation from wind and solar energy is increasing rapidly, but the share of renewable energy sources remains relatively small (7.5% in 2018) (Hubei DRC, 2019b). Decarbonisation of the energy generation sector in Hubei is a mounting task facing the provincial authority.

[20] The Hubei Electricity Trading Centre has been operating since January 2017. And the Guangzhou Electricity Trading Centre was established in March 2016. However, the observation from the industry suggests that the establishment of electricity trading centers does not mean the establishment of the electricity trading market (Feng, 2016).

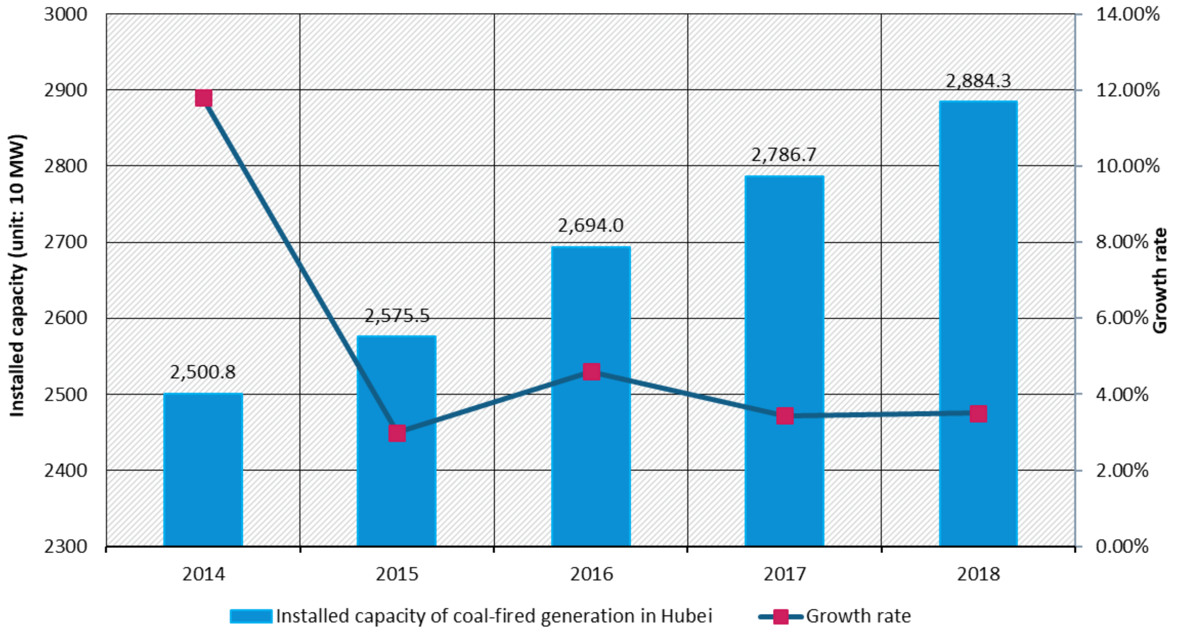
Table 8: Energy Development in Hubei Province during the 12th Five-Year Plan Period (2011-2015)

Category	Index	Unit	2010	2015	Average annual change
Energy Production	Indigenous Production	10,000 Tons of Standard Coal	5331	5256	-0.3%
	Among them, coal	10,000 Tons	1292	860	-7.8%
	Crude oil	10,000 Tons	87	71	-4%
	Natural Gas	100 million Cubic Meters	1.97	1.35	-7.2%
	Total Electricity Production	100,000 MWh	2017	2356	3.2%
Electric Power Development	Installed Capacity	10 MW	4908	6410	5.5%
	Among them; Thermal Power	10 MW	1816	2576	7.2%
	Hydroelectric	10 MW	3085	3653	3.4%
	Wind Power	10 MW	5.72	135	88%
	Solar	10 MW	0.34	49	170%
Energy Use	Total Energy Consumed	10,000 Tons of Standard Coal	12764	16404	5.15%
	Coal	%	63.5	55.9	[-7.6]
	Petroleum	%	17	22	[5]
	Natural gas	%	1.5	3.4	[1.9]
	Non-fossil Energy	%	18	18.7	[0.7]
	Total electricity consumption	100,000 MWh	1330	1665	4.6%

Source: 13th Five-Year Plan for Energy Development in Hubei Province.

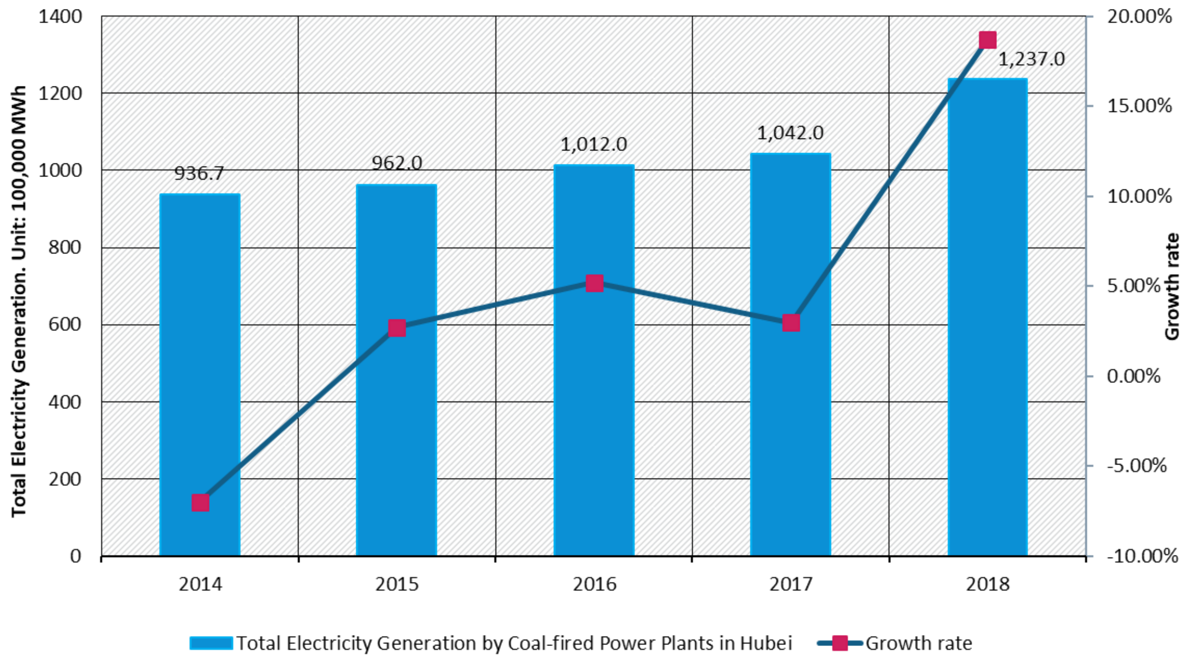
As the graphs below show, the increasing reliance on coal for electricity production explains the rapid growth of Hubei's coal-fired generation capacity, the electricity it produces, as well as the higher operating hours of coal-fired power plants in Hubei in recent years.

Figure 3: Installed Capacity of Coal-fired Generation in Hubei from 2014-2018 (Unit: 10 MW)



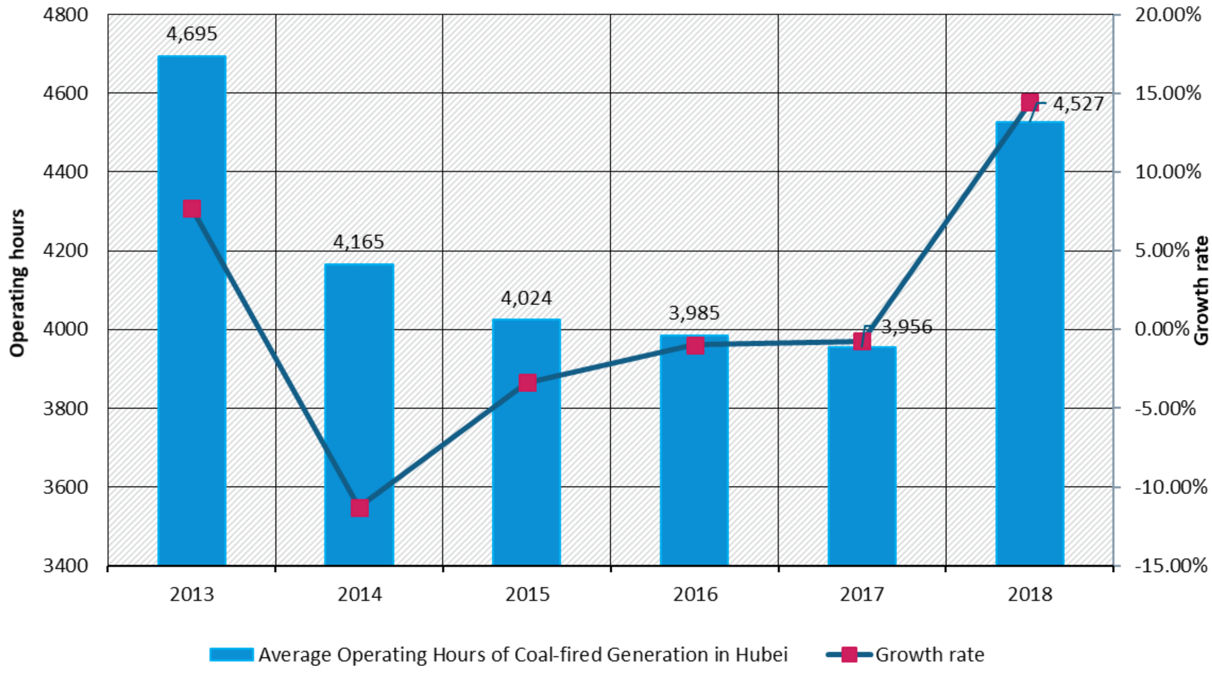
Source: By authors based on Hubei's statistical yearbooks 2015-2019.

Figure 4: Total Electricity Generation by Coal-fired Power Plants in Hubei 2014-2018 (Unit: 100,000 MWh)



Source: By authors based on Hubei's statistical yearbooks 2015-2019.

Figure 5: Average of Operating Hours of Coal-fired Generation in Hubei 2013-2018 (Unit: Hours)

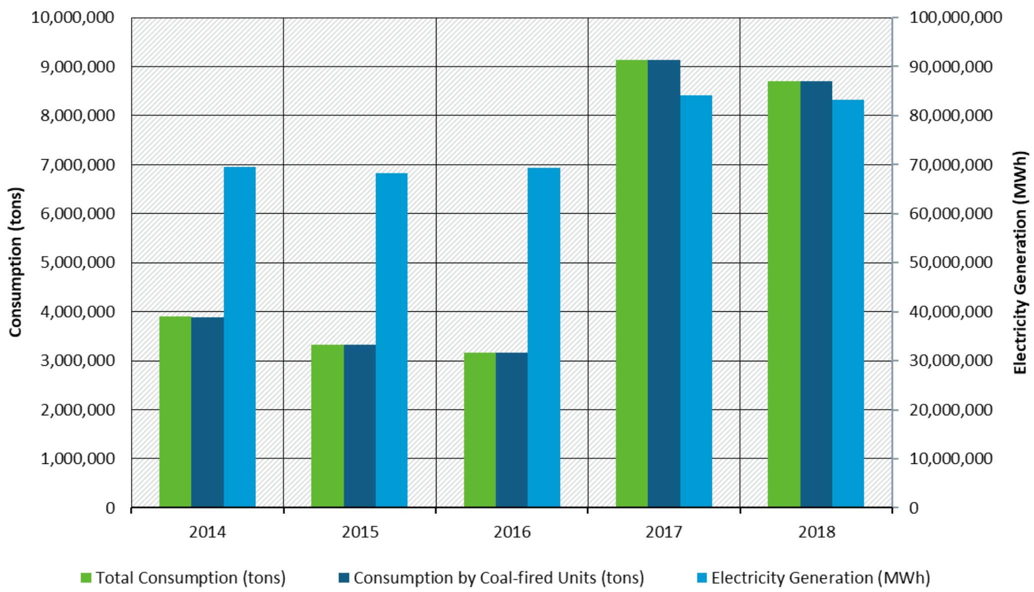


Source: By authors based on Hubei's statistical yearbooks 2015-2019.

Installed capacities and generation mix, Shenzhen

The capacity mix in Shenzhen means that its coal consumption is largely dependent on Ma Wan Electric Power, which runs the coal-fired units. To recall, among the 8 entities in Shenzhen's power sector covered by the ETS, 7 operate gas-fired units and only one entity has coal-fired generation assets. In addition, Shenzhen also relies on nuclear power and waste-to-energy, but these units play a smaller role in sustaining Shenzhen's electricity supply. According to the relevant data, the total coal consumption in Shenzhen slightly decreased from 2017 (9.14 million tons) to 2018 (8.7 million tons), after a significant increase from 2016 to 2017. However, due to the lack of information disclosure, the data on fuel mix and generation capacities are not publicly available. According to Shenzhen's statistical yearbook in 2018, the sharp rise of coal consumption results from power generation and heat supply. The increase of electricity demand from Shenzhen's manufacturing and building sectors has driven up the coal consumption by power generation. In the meantime, the heating demand by these sectors has also contributed to the increasing share of coal use in Shenzhen's energy mix.

Figure 6: Coal Consumption and Electricity Generation in Shenzhen 2014-2018



Source: By authors based on Shenzhen's statistical yearbooks 2015-2019.

As a municipal city that has a large economic output and limited generation capacity, Shenzhen must rely on electricity imports to meet its growing demand, but no information on import volumes is available. Due to the higher price of gas, coal-fired generation units are preferred as a back-up plan to meet the demand, often leading to higher consumption of coal, as shown in the year 2017 (see figure 6). The market structure in Shenzhen means that it encounters a large amount of indirect emissions, i.e. emissions connected with the import of electricity.

Age of plant fleet, ownership

In terms of the fleet age, coal-fired power plants in Hubei vary across different localities, ranging from 1 year to 27 years, with a regular average age of 12.9 years, which is slightly younger than the average 14 years of China's coal-fired power fleet.[21] The capacity-weighted average age of Hubei's coal-fired plant is 15.6 years.[22] Hubei's hydropower plants were mostly built between the 1980s and early 2000, with the oldest hydropower plant operating from the 1970s and retrofitted in the 1990s and 2000s. Hubei has also seen a significant increase of renewable energy uptake in recent years. The renewable plants are relatively young because most generators were built from 2010 onwards after the promulgation and amendment of China's Renewable Energy Law in 2006 and 2009, respectively.

Regarding ownership, the majority of Hubei's coal-fired power plants are owned by state-owned enterprises (SOEs), including both SOEs owned by central government and provincial government. Most of the 'big five' energy SOEs, such as Guodian Corporation (now China Energy Group), Huadian and Huaneng, have their presence in Hubei, with China Energy Group owning the most generating assets. Based on a rough calculation by the authors using the available data as of 2016, central SOEs own around 85% of Hubei's coal-fired power generation capacity, followed by provincial SOEs which account for around 10%.[23]

For Shenzhen, the only coal-fired plant, Ma Wan Electric Power, has been operating for 26 years (Carbon Brief, no date). Shenzhen's thermal power plant fleet is dominated by gas units and the

[21] Author's own calculation based on the data from Carbon Brief.
[22] Author's own calculation based on the data from Carbon Brief
[23] Author's own calculation based on the data from Global Energy Monitor.

average age of gas units in Shenzhen is lower, with the most recent two units built during the 11th Five-year period (2006-2010). State ownership dominates Shenzhen's power sector with the majority of power generation units owned by SOEs.

6.2 Wholesale market and dispatch

6.2.1 Electricity pricing

China's electricity prices, including on-grid electricity tariffs, have undergone several stages of adjustments since the initial reform in 1985. The initial reform on pricing was part of the efforts to address the pressing issue of electricity shortage and to mobilise investment in China's power generation. A system of multiple on-grid tariffs was introduced in 1987 and different tariffs were calculated based on the sources of funding and owners of the power generating units, often on a project-by project basis (MEPHR, 1987). To curb the development of multiple tariffs, the Electric Power Law of China, which was promulgated in 1996, establishes the overall principle that "the electricity tariffs shall be decided based on a centralised policy, fixed in accordance with a unified principle and administered at different levels" ("Electric Power Law", 1995, art. 34, para. 2).[24] For electricity tariffs, the Electric Power Law further stipulates that "establishment of electricity tariffs shall compensate reasonable costs, allow for reasonable profits, incorporate relevant taxes, reflect the fair sharing of project costs, and promote development of the power sector" (ibid, art. 36). Importantly, the Law contains a provision that "[a] principle of equal on-grid tariffs shall apply to the equal quality of electricity supplied by the same electricity network" (ibid, art. 37). Although this provision is never implemented to its full capacity in practice, it paved the way for a new tariff scheme known as the operational-period tariffs which amortised investment costs over the expected operational rather than financial lifespan of the power plants (SDPC, 2001).[25] This new tariff scheme was formalised in 2001 so as to reduce the cost of developing coal-fired plants and thus the on-grid tariffs. As part of the milestone reform in 2002 to break down the vertical integration of China's power sector, the electricity tariffs were categorised into on-grid, transmission and distribution, and sale prices (State Council, 2003).

Since 2004, on-grid tariffs for coal thermal generators in China have been set using benchmark pricing, in which new generators coming into operation after 2004 and falling into the same technology class are given the same tariff (NDRC, 2004, part 3, para. 1). The tariff is decided by the Department of Pricing under the NDRC and it is based on an estimate of the average cost of industry-wide technologies and performance in each province (ibid). In response to environmental pollution caused by SO_2 emissions, coal-fired installations with desulphurisation facilities were noted in particular to receive higher on-grid tariffs (ibid). On top of the benchmark on-grid electricity tariffs, newly built power generation with desulphurisation facilities installed were allowed to charge an additional 0.015 CNY per KWh electricity produced (NDRC and SEPA, 2007, art. 4). The same surcharge was also granted to existing installations after their deployment of facilities being approved by the environmental protection agency at the respective government level (ibid, art. 5).

Greater recognition of the degree of environmental degradation has led to a more proactive role for pricing in shaping the environmental outcomes of China's power generation sector. The incentive to reduce SO_2 emissions through additional on-grid tariffs has been extended to reward investment into facilities that reduce NO_X emissions and ashes (NDRC, 2013). The environmental protection agencies at various levels of governments have the authority to

[24] The section on electricity pricing remains the same from its 1996 version.
[25] The operational lifespan of a coal-fired plant was set for 20 years.

monitor and verify the level of pollutants discharged by the coal power generating units, and thus approving whether the coal-fired generating units are qualified for a higher tariff. Coal-fired plants with NO_X emissions lower than the environmental standard are entitled to an additional 0.01 CNY/KWh in the on-grid tariff (ibid, part 3). Coal-fired installations that discharge less than 30 mg/m^3 (and 20 mg/m^3 in some areas with severe air pollution) are allowed to charge 0.002 CNY per KWh on top of the benchmark tariff (ibid). The additional tariffs with environmental protection objectives are collectively known as the 'environmental on-grid tariff' (NDRC and MEP, 2014). To ensure operation of these environmental protection facilities and sufficient supervision, the coal-fired generation units are required to install the continuous emission monitoring system (CEMS), and to connect the system with the data receivers located at both the provincial environmental protection agencies and the grid companies (ibid, art. 8).[26] The timely monitoring of the level of pollution is to safeguard the environmental on-grid tariffs are paid in exchange for genuine reductions of atmospheric pollutants. As highlighted by several interviewees, there is also a strong need to deploy CEMS to monitor CO_2 emissions and ensure data quality in China's coal power sector.

To further incentivise coal-fired plants to reduce their environmental impact, the NDRC has reduced the benchmark on-grid tariffs twice since 2014. The reduction in 2014 was a cautious movement, with an average drop of the benchmark tariff of around 0.009 CNY/KWh nationwide (NDRC, 2014). In 2015, the NDRC lowered the on-grid tariff by another 0.03 CNY/KWh (NDRC, 2015). In both of the policy documents, the NDRC has explicitly stated that these reductions are made to compensate payments for environmental on-grid tariffs, so as to highlight the importance of environmental on-grid tariffs in the total revenues of coal-fired generation (NDRC, 2014; NDRC, 2015). Along with the drop of benchmark tariffs, the NDRC has also increased the environmental on-grid tariffs to coal-fired generation with 'ultra-low emissions'. An additional tariff of 0.01 and 0.005 CNY/KWh applies respectively to existing plants and new installations in operation after 1 January 2016 (NDRC et al, 2015). The concept of 'ultra-low emissions' consolidates the separate standards adopted and implemented by the previous policies regarding major pollutants inter alia SO_2, NO_X and ashes (less than 10 mg/m^3, 35 mg/m^3, and 50 mg/m^3 respectively) (ibid, part 1). The higher tariff is to be implemented till the end of 2017 and starting from 2018, the difference in tariffs between existing and new plants will gradually diminish (ibid). Provincial governments are allowed and encouraged to set more stringent standards for emissions and to set an associated fiscal reward for the coal-fired generating units.

As a cornerstone of the 2015 reform of electricity pricing, assessment and determination of the T&D tariff is required to follow the principle of 'approved cost plus reasonable profit' (State Council, Annex 1, 2015, part 1). The approved cost of grid companies consists of depreciation of equipment and cost for operation and maintenance (NDRC and NEA, 2015). Each category of cost is specified to reduce discretion in the process of assessing and determining T&D tariffs (ibid).[27] The T&D tariffs, together with the amount of governmental funds collected through surcharges (e.g. used for renewable feed-in tariffs) and cross-subsidisation, are to be publicised for public scrutiny and supervision (ibid). Cross-subsidisation between commercial and industrial users will gradually diminish (ibid, part 3(3)). The grid companies are entitled to report the amount of such cross-subsidies to the governmental pricing bureaus for approval so

[26] This Regulatory Measures has replaced the Interim Measures for the Operation and Management of Desulphurization Facilities for Coal-fired Generating Units and the related Electricity Price.
[27] For example, the operation and maintenance cost is defined in article 14 to include the cost of materials, fixture and staff salary. When considering staff salary and other related expenses in the assessment and determination of T&D tariffs, the Interim Measures cap the percentage of the such expenses in the overall staff salary. The specific percentage includes staff welfare (14%), housing provident funds (12%), staff education funds (2.5%) and funds for trade union activities (2%).

as to collect the difference through T&D tariffs at a later stage (ibid). Part of the overall objectives of reviewing the T&D tariffs is to understand the cost of T&D, as well as the complicated structure of cross-subsidisation that has been implemented by the grid companies on behalf of the governmental regulatory agencies (ibid). As discussed below, the re-assessment of T&D has led to the decrease of electricity sale price which benefits the industrial end-consumers. But the reform has yet to change how the on-grid tariff is determined to allow passing through of the additional cost from GHG emissions to end-consumers.

Electricity pricing and markets in Hubei and Guangdong (incl. Shenzhen)

For the moment, changes at the national level in the area of pricing apply to both Hubei and Guangdong (including Shenzhen). Electricity pricing in both Hubei and Shenzhen is still largely based on administrative decisions made by the NDRC. The major difference between the two localities includes the different progress towards cautious liberalisation of pricing deregulation, both in wholesale and retail market. The electricity markets in Hubei and Guangdong are still in transition, and can therefore be considered as "hybrid", i.e. combining aspects of natural monopoly regulation and aspects of market liberalisation. Following the "textbook" approach to electricity market reform, the grid companies in Hubei and Shenzhen are regulated as natural monopoly. However, by contrast to the principle of functional unbundling according to which network companies are not supposed to be involved in the sale-purchase of electricity, the grid companies in Hubei and Shenzhen buy electricity from generators at the "on-grid tariff" and resell that electricity to end users.

Both on-grid tariffs and retail prices are centrally determined by the Pricing Bureau of the NDRC, subject to some minor adjustments by the provincial authority. As the 2015 reform progresses, the ("hybrid") liberalised market allows industrial users – above a certain level of electricity demand – to enter into electricity sale contracts directly with power generators, or through an officially recognised retailer and therefore the prices can be negotiated and determined accordingly.

The re-assessment and calculation of T&D tariffs – an essential part of the 2015 reform – serves two important purposes. First, with re-assessment, the government aims to improve the transparency of T&D tariffs and so drive down transportation costs, to the benefit of end consumers. The second purpose is to facilitate the transformation of the grid company from a residual (and subsidy) collector to a public utility company.

In sum, grid companies are to charge T&D tariffs approved by the relevant authority. By contrast, for electricity supply to industrial consumers, the 2015 reform allows that, the price of electricity, other than the T&D tariff, is freely determined by the contractual parties.

In practice, the re-assessment of T&D tariffs has resulted into a reduction of the cost of transportation. In Shenzhen, from 2015 to 2017 – the trial phase of T&D tariff re-assessment – tariffs were set at 0.1435, 0.1433, 0.1428 CNY/KWh respectively (NEA, 2016). Compared to 2014 tariff levels – 0.1558 CNY/KWh – the new T&D tariffs achieved a reduction of at least 0.01 CNY (ibid). In Hubei, the average T&D tariffs between 2016 to 2018 amounted to 0.2374 CNY/KWh (NDRC, 2017) – a reduction of 16.3% in comparison to previous tariff levels (ibid).[28]

6.2.2 Wholesale market

The wholesale market in Hubei and Guangdong is still in its infancy. According to the interviewees, the trading of electricity on the wholesale market only represents a small share in Hubei (21%) and Guangdong (around 20%). Most of the trading takes place on the basis of

[28] In addition to Hubei, the second batch of provinces include Yunnan, Guizhou, Anhui and Ningxia.

yearly contracts. In Guangdong, around 4-5% of the market trading is via monthly contracts. Day-ahead trading is allowed but it is yet to be formed either in Hubei or Shenzhen.

The price of electricity in annual and monthly contracts is formed on the basis of negotiation and mutual agreement between the industrial users and power generators/retailers. The day-ahead market is also mentioned as a potential component for market trading, but it is considered part of the mid-and-long-term goal (for 2020 onwards). The day-ahead market price is determined through bidding, subject to a price cap and floor. It is, however, unclear how price caps and floors are determined (Hubei Provincial Energy Bureau, 2018).

In practice, many electricity contracts continue to refer to the government benchmark prices as the basis of electricity price formation. This means that power generators remain subject to a certain degree of price regulation. The fixed price includes environmental-related mark-ups, including additional tariffs relating to the removal of air pollutants and ashes, and tariffs rewarding ultra-low emissions. The Hubei provincial government encourages market participants to initiate bilateral negotiations and establish a price formation mechanism using 'benchmark + floating electricity price'. Under this mechanism, both parties to the transaction take into account factors such as the price of coal for power generation so that they can implement a price co-movement and specify the price enforcement clause mechanism in the agreement (Hubei Provincial Energy Bureau, 2019).

During the early stage of market trading (i.e. 2018-2019), the provincial authority in Hubei also requires that cost reductions achieved in electricity production and transportation are reflected in end-use electricity prices, resulting in lower electricity costs for consumers (Hubei Provincial Energy Bureau, 2018, part 5(5)).

In Guangdong, the government benchmark price also works as a reference point for wholesale prices. Detailed information in this regard is subject to contract confidentiality requirements and is thus not publicly available. Interviewees indicated that the deviation between the benchmark price and wholesale price is rather marginal for annual contracts and the agreed price in monthly contracts normally fluctuates around the benchmark price within a small range.

6.2.3 Electricity dispatch

The fast expansion of coal power generation has been underpinned by China's Electric Power Law of 1995, in which a guaranteed investment return and regulated pricing are established to attract private investments. Accordingly, when it comes to dispatch, the *Regulation on Power Grid Dispatch* which was promulgated in the early 1990s has set the basic tone for access to the network by power generators (MEPI, 1993). Historically, grid operators in China have allocated the operating hours equally among coal-fired generators which account for the majority of China's electricity generation capacity (ibid). This approach is to ensure fairness among investors with coal-fired generating assets to produce enough electricity so as to gauge reasonable investment returns. Provincial development and reform commissions have the administrative power to set annual operating hours for generators, subject to approval by the NDRC. This particular Chinese 'equal dispatch' is very distinct from most other countries where grid operators dispatch generators based on their marginal cost in a given fuel type (such as coal or gas) (Kahrl et al., 2013). To date, the equal dispatch remains largely unchanged, leading to massive investment in China's power sector, including in coal-fired power plants.

A major force to reform the dispatch system in China is generated by the fast development of renewable energy and its regulatory framework that aims to ensure "priority access" of renewable energy to the grid network. But so far, the reform efforts to change the dispatch sequence in China have been unsuccessful. In 2007, the NDRC implemented a trial of energy efficiency dispatching (also known as energy conservation dispatch) in a number of provinces (NDRC et al, 2007). With the policy goals of "increasing power generation efficiency, conserving energy, reducing environmental pollution and advancing structural change for the electricity sector," the green dispatching aims to establish the dispatching sequences based on the level of energy efficiency of each unit and the amount of pollutants discharged. Subject to the requirement that it does not pose a threat to the stable operation and reliability of the electricity system, the green dispatching prioritises renewable energy access to the network in the list of sequence for dispatching based on the type of unit, which is as follows: 1) non-dispatchable renewable energy; 2) dispatchable renewable energy; 3) nuclear; 4) combined heat and power (CHP) generation units where electricity is the by-product; 5) natural gas and gasified coal generation units; 6) coal-fired generators; 7) oil. The trial program was first initiated in five provinces (including Jiangsu, Henan, Sichuan, Guangdong and Guizhou). However, implementation of the program has faced some significant resistance from provincial authorities in the subsequent rollout to other provinces, including Hubei (NEA, 2015).

Although green dispatch was able to deliver some positive outcomes for energy efficiency improvement and cost savings (ibid), the benefits proved to be rather marginal, in contrast with the adverse effects that the trial programs have generated in practice. The National Energy Administration (NEA) report provided some specific examples of the impact at the provincial level in the process of experimenting green dispatch (ibid). It found that, in the process of formulating and implementing the annual plan for electricity generation, the Hunan provincial government had deliberately linked the electricity generation quota to purchasing local coal. In addition, the Hubei provincial government interfered with the sequence of green dispatch by prioritising selected medium-sized coal-fired generation units (ibid).[29] The operating hours of these selected units were, on average, nearly the same as the yearly operating hours of the larger units despite their higher efficiency level (ibid). The province of Sichuan reverted to administrative control of operating hours for generators after the trial of green dispatching for four years (ibid).

The limited success of green dispatch did not prevent the central government from carrying out further reforms. As part of the policy framework for electricity sector reform in 2015, the State Council issued a regulatory document in order to 'promote reform of the planning system for electricity generation and usage' (State Council, Annex 4, 2015d). The document, titled *Implementation Opinions on Deregulating the Plans for Electricity Generation and Usage*, adopts a tier system to indicate sequence of priority access to the network by different types of generators. The top tier priority includes: a) renewable energy generators that are included in the overall national or provincial energy development plan; b) coal-fired generators that are responsible for peak loading and frequency modulating; and c) CHP units that ensure heating supply and meet the environmental requirements (ibid). Clean energy that is part of the national or local plan for cross-region transmission, such as hydro, nuclear and other generators with ultra-low emissions are included as second tier priority. Within each tier, provincial authorities are given discretion to decide the sequence of priority, "based on real conditions of the region and in accordance with the principles of ensuring grid safety and taking into account issues such as cost and system flexibility" (ibid).

Although renewable energy is placed in the first tier for priority access, the tier system in fact legitimises priority access by certain coal-fired generators and CHP units. As observed by some interviewees, the latest reform is considered as a compromise after the failure of "a more radical

[29] The report doesn't explain the reason for this, but a possible explanation is that these medium-sized coal-fired generation units are owned by provincial enterprises and they are given de facto priority in the dispatch sequence.

approach adopted by the green dispatch." In Hubei, for example, the reform process has been extremely difficult, due to a range of factors including local protectionism (protecting local industry), and the strong resistance from the grid companies as well as stakeholders with strong vested interest.

Dispatch in Hubei and Guangdong are yet to be fundamentally changed despite the gradual opening up of the electricity sector towards market trading. Essentially, administrative authorities in both localities manage dispatch sequence based on pre-allocated operating hours among generators. In Hubei, the Department of Electricity Dispatch under Hubei DRC centrally manages the dispatch of major coal power generators across Hubei. As of 2019 a total of 55 generating units in Hubei with a capacity of 200 MW and above are centrally dispatched. In Guangdong, as discussed further in section 7.2, the enabling of a wholesale market in the province has not altered the dispatch sequence. As of 2017, among the generating units that are subject to administrative dispatch, nearly 69% are fossil fuel intensive (Southern Supervision Bureau of NEA, 2018). In the context that in 2017 peak load electricity demand (108,600 MW) in Guangdong is slightly more than its totally installed generation capacity (107,800 MW), ensuing system reliability and security is a priority in managing the electricity system and administrative dispatch is preferred to achieve this goal (Kahrl et al., 2019).

6.3 (Dis-)Investment and interacting policies

6.3.1 Regulation of generation investments and disinvestments (closures)

The regulation of electricity investments in China is a dynamic process in which both the investment decision-making by the company and the investment approval by the regulator determine the development of China's power generation industry. The early reform measures in the 1990s and 2002 placed energy companies at the centre of the investment-making process. From then, companies made investment proposals to be approved by the government (Boute & Zhang, 2018; Cunningham, 2015). During the reform process, approval of power generation projects was transferred back and forth from the central government to the provincial administration. Since 2013, the overall trend is delegation of approving authority to provincial and lower level governments. In May 2013, the State Council decided to delegate some of the approval authority over investment decisions to lower level of governments (State Council, 2013). The authority of approving new investments in energy efficient power generation projects, including distributed gas power generation and coal-fired CHP units with back-pressure steam turbines, are delegated to provincial governments (ibid).[30] Similarly, the authority to approve investments in hydroelectric power on non-major rivers and wind farms has been delegated to local authorities (ibid). Soon after this initial effort towards the decentralisation of approval authority, the NEA announced in January 2014 that approving investments into conventional coal-fired plants would also be gradually delegated to provincial governments (NEA, 2014).

By early 2015, the approval process for new coal-fired generation had been officially decentralised to lower-level governments (State Council, 2014). According to the *List of Investment Projects that Require Government Approval (2014 Version)*, local governments have the most extensive authority to approve both the CHP units and wind power projects (as shown below in the case of Hubei and Shenzhen).

Along the same line, the former Ministry of Environmental Protection delegated its authority of review and approval of the Environmental Impact Assessments of investments in coal-fired

[30] These changes were later on confirmed in the more general guidelines regarding investment approval.

generation and co-generation units to the provincial department of environmental protection (MEP, 2015).

Against this backdrop of decentralisation and delegation of approving authority, the process of approval has been accompanied with a significant surge in new coal generation projects. A recent study suggests that a total of 210 coal-fired generation projects were listed in 2015 by the environmental protection agency for EIA process, of which 195 projects, with a total capacity of 159 gigawatts, were ready for clearance (Myllyvirta et al., 2016). In contrast, the total approved capacity in 2014 was 49 gigawatts (ibid). Worth noting, however, is that the average operating hours of coal-fired generation in China is 4165 in 2016, which is the lowest level since 1964 (NBS, 2016). As a result, coal-fired generation units are under pressure. According to the China Electricity Council, the cumulative hours of China's coal-fired plants in operation in 2015 are 4329 on average, which is 377 hours lower than the previous year (CEC, 2016a). China's Central Environmental Inspection Group, in its investigation report published in January 2021, openly criticised the NEA for failing to limit the expansion of coal power plants and falling behind on promoting the development of low-carbon energy (NEA, 2021). Observers described the tone of criticism as "unprecedented" in China's modern history and "[n]ever before has a high-level central government agency been inspected and openly criticised for multiple 'failures' related to energy development" (Xie, 2021).

Practically, these measures demonstrate the challenges of using price signal (ETS and deregulated electricity price) to decarbonise China's power supply. The existing regulatory framework of China's electricity sector is still volatile due to the uncertain fate of the 2015 reform. As discussed in the next section, the 2015 reform has diversified the market participants and allowed a certain level of flexibility of grid operation at the provincial and local level. However, the changes so far are unable to fundamentally change the formation of electricity pricing (especially on-grid tariffs) and dispatch sequence.

6.3.2 Capacity markets

China does not have a capacity market. Interviewees suggest that the need for a capacity market in China is less urgent due to over-capacity of coal-fired generation, as the reliable generation units (such as hydro and coal-fired generation units) are mainly constructed by state-owned enterprises. Considering the relatively low financing cost and less pressure to secure investment returns, state-owned enterprises are better placed to install more generation capacity, leading to over-supply of electricity in China (Myllyvirta et al., 2015). Therefore, the challenge facing China is how to reduce the overall capacity in the coal-fired power sector, instead of securing sufficient capacity to safeguard system reliability.

6.3.3 Companion policy investment drivers in Hubei

Hubei has adopted provincial policies to promote the development of clean energy and the policy imperatives include:

a) Enhancing hydropower development in western Hubei and north-western Hubei, to build new hydropower stations in Hanjiang River Basin, Loushui River Basin, and Qingjiang River Basin, to increase installed capacity of hydropower in Hubei by 1500 MW.

b) Promoting the large-scale replacement of coal-fired power by non-hydro renewable energy. Accelerating development of distributed photovoltaic power generation, and moderately promoting the construction of solar farms, with new installed capacity of up to 3000 MW. By 2020, the cumulative installed capacity will be increased to 3500 MW, of which distributed photovoltaic power generation accounts for 50%.

c) Actively promoting the comprehensive and efficient use of biomass energy and increasing the installed capacity of biomass power generation by 350 MW. By 2020, the cumulative installed capacity should reach up to 1000 MW.

d) Developing and utilising wind power to promote the construction of decentralised wind power projects with suitable wind energy resources and close to the load centre. The target for new installed capacity of wind power is expected to be 3600 MW. By 2020, the cumulative installed capacity is to reach up to 5000 MW (Hubei Government, 2016, ch. 3, section 3).

Descriptions of energy efficiency regulation

At the national level, stricter energy efficiency and environmental standards are designed to direct new investments to be cleaner and low carbon and, in the meantime, to eliminate small and old installations that are dirty and less efficient (see table 11) (Boute & Zhang, 2018). The national energy efficiency regulation also applies to Hubei. For energy efficiency, existing plants that refuse to retrofit or fail to meet the required energy efficiency standard (310 g standard coal-eq and below per KWh electricity generated) after retrofitting, will have restricted access to resources and eventually face elimination (NDRC and NEA, 2016a).

New investments that do not satisfy the required energy standard (300 g standard coal-eq and below per KWh electricity generated) will be disapproved for planning and thus construction (ibid). It must be noted that large and more efficient coal-fired plants tend to be owned by the central SOEs whereas small and medium generators are more likely to be owned by provincial and local governments (CEC, 2016b).

There are thus strong "companion" policies in place to reduce the energy – and thus carbon – intensity of power generation in China, including in Hubei. Direct regulation co-exists with the ETS, in order to achieve emission reductions (Boute & Zhang, 2018).

Table 9: Binding Targets for China's Coal Power Sector During the 13th Five-Year Plan Period (2016-2020)

Name of target	Details of target by 2020	Bound entities	Enforcing agencies	Implications of non-compliance
Energy efficiency of existing coal power plant	310 g standard coal-eq and below per KWh electricity generated (reduced from 318 g in 2015)	Coal-fired power plants	NDRC and NEA	Restrictions to access to resources (e.g., water) and facing elimination
Energy efficiency of new coal power plant	300 g standard coal-eq and below per KWh electricity generated	Coal-fired power plants	NDRC and NEA	Disapproval for construction
Pollutants discharged by coal power generation	Less than 35 mg SO2, 50 mg NOx and 10 mg ashes per every cubic meter of emissions discharged	Coal-fired power plants	NDRC and MEE	Restrictions to access to resources (e.g., water) and facing elimination

Source: The 13th Five-Year Plan for Electricity Development (2016-2020).
Note: MEE – Ministry of Ecology and Environment.

6.3.4 Companion policy investment drivers in Shenzhen

Renewable targets

According to Shenzhen's 13th Five-year Plan for Energy Development, Shenzhen has adopted three binding targets to reduce the use of fossil energy (Shenzhen DRC, 2016b). First, Shenzhen aims to limit the total primary energy consumption to 45 million tons of standard coal by 2020, which is 5.9 million tons more from the 2015 level. Among the different types of energy consumption, the expected targets are to reduce the share of coal consumption from 6.4% to 4.6% and to increase the natural gas usage to 17.2% from the 2015 level (which is 12.7%).

Second, Shenzhen aims to ensure that non-fossil (i.e. renewable) energy consumption shall account for more than 15% of primary energy consumption (ibid). In 2015, non-fossil energy consumption already took up 15% of Shenzhen's primary consumption. Taking into account the national target for 2020 (which is 15%), Shenzhen's target to decarbonise the energy supply is not considered to be progressive by the interviewees.

Third, Shenzhen aims to reduce the intensity target of energy consumption per unit GDP from 19.87% to 18.5% by the end of 2020. Clean energy generation (89% of total installation capacity by 2020) is also included as part of the Five-year Plan but the target is expected rather than binding.

Energy efficiency regulation

During the 13th Five-year Plan period, the Shenzhen Municipal Government aims to achieve an annual increase of 20% in its energy conservation and environmental protection industry (Shenzhen Government, 2014). This target is underpinned by support and investments into technology innovation that promotes clean energy generation (desulphurisation and pollutant removal) and energy efficiency improvement in industrial and building sectors (ibid). The national standards in relation to energy efficiency and environmental standards, as discussed above in the Hubei case study, also apply to Shenzhen.

To reiterate, for energy efficiency, existing plants that refuse to retrofit or fail to meet the required energy efficiency standard (310 g standard coal equivalent and below per KWh electricity generated) after retrofitting, will have restricted access to resources and eventually face elimination (NDRC and NEA, 2016a). New investments that do not comply with the required energy standard (300 g standard coal equivalent and below per KWh electricity generated) will be disapproved for planning and thus construction (ibid).

Similarly, to Hubei, China's national performance standards co-exist with the ETS in Shenzhen, with a common goal to reduce the energy intensity of power generation and thus achieve emission reductions (Boute & Zhang, 2018).

6.4 Retail market and consumer price regulation

Like the on-grid tariff, the retail electricity prices in China have long been regulated by the government.[31] According to the nature of electricity consumption, retail prices in China are divided into four categories, including residents, agriculture, large industry, and general industry and commerce. Among them, the price for general industry and commerce is the highest, followed by large industry, residential usage and agriculture. The retail price of

[31] As the retail market in China is still at its infancy, the term 'retail price' refers to both sale price of electricity by the grid company (under the regulated market) and price of electricity by retailers (through market trading).

electricity in China is dependent on the purchase cost of electricity from generation (on-grid tariff), cost of electricity losses from T&D, T&D tariff and government surcharges.

According to the Annual Report on National Electricity Price Supervision in 2018 which was issued by the NEA, the retail price of electricity differentiates greatly across the provinces (including autonomous regions and municipalities) in China, with an average price of 599.31 CNY/MWh (NEA, 2019). Shenzhen has the highest average electricity price at 747.00 CNY/MWh, due to the higher price of fuels, and Qinghai Province's electricity price is the lowest, priced at 346.68 CNY/MWh which is around 57.8% of the national average (ibid). Hubei's electricity price is also on the higher range, with an average of 642.86 CNY/MWh (ibid). Due to the re-assessment of T&D tariffs which leads to lower T&D tariffs in most provinces,[32] the average price has been reduced by 1.61% nationwide, as compared to the 2017 level (see table 12).

Table 10: Average Retail Price of Electricity in Hubei, Shenzhen, and Guangdong (excluding Residential Sector) 2017-2018

	2018 (CNY/MWh)	2017 (CNY/MWh)	Change (%)
National Average	599.31 (75.57 EUR)	609.10 (76.81 EUR)	-1.61%
Hubei	642.86 (81.06 EUR)	647.75 (81.68 EUR)	-0.75%
Shenzhen	747.00 (94.19 EUR)	767.74 (96.81 EUR)	-2.7%
Guangdong	635.76 (80.16 EUR)	653.16 (82.36 EUR)	-2.66%

Source: Annual Report on National Electricity Price Supervision in 2018.

The formation of electricity retail prices in China is complicated because the price also contains a range of surcharges and the level of those surcharges are established by the central government. These surcharges are collected to contribute to the national development funds to facilitate construction of relevant energy projects. In a nutshell, the national development funds that require surcharges in the retail price of electricity include the National Major Water Conservancy Project Development Fund, the Rural Power Network Repayment Loan Fund (applicable to certain provinces only), the Reservoir Resettlement Support Fund, and the Renewable Energy Development Fund.

Using Shenzhen as an example, the breakdown of surcharges in Shenzhen in 2018 includes 3.9 CNY (0.49 EUR)/MWh (national major water conservancy project development fund), 6.2 CNY (0.78 EUR)/MWh (large and medium-sized reservoir resettlement support fund), 0.5 CNY (0.06 EUR)/MWh (small reservoir resettlement support fund) and 19 CNY (2.40 EUR)/MWh (renewable energy development fund), with a total of 29.60 CNY (3.73 EUR)/MWh (NEA, , 2019).

[32] Despite of the overall decease of T&D tariffs, the re-assessment of T&D tariffs in the regional grid networks of Beijing and northern Hebei, however, turns out to be higher than previous level. On the one hand, the increased T&D tariffs in the two regions are largely driven by the expanded investments in the transmission and distribution networks, as well as the weak increase of electricity demand. The NDRC and the NEA, on the other hand, has decided not to increase the T&D tariff. See "Reply from the NDRC Official on Determination of the Transmission and Distribution Tariffs", 2017.

In Hubei, the cumulative surcharges in 2018 are priced at 39.92 CNY/MWh. Following the trend of decreases in retail price, there is also a significant drop of surcharges in 2018 but the reduction in both Hubei and Shenzhen is rather marginal.

Table 11: Surcharges contained in the Electricity Retail Price in Hubei and Shenzhen 2017-2018

	2018 (CNY/MWh)	2017 (CNY/MWh)	Change (%)
National Average	29.67 (3.73 EUR)	36.83 (4.64 EUR)	-19.46%
Hubei	39.92 (5.03 EUR)	41.20 (5.19 EUR)	-3.11%
Shenzhen	29.60 (3.73 EUR)	30.90 (3.90 EUR)	-4.21%

Source: Annual Report on National Electricity Price Supervision in 2018.

Although not directly shown in the formation of retail prices, cross-subsidisation is also an integral part of the pricing system in China, which is often included in the calculation of T&D tariff. The general principle is that additional payments are made by certain groups of consumers to compensate others (Wang & Li, 2017). For now, cross-subsidisation in China is provided in the following approach:

a) subsidies for users in less developed regions by users in developed regions within provinces (autonomous regions and municipalities);

b) subsidies for low-voltage users by high-voltage users;

c) subsidies for residents and agricultural users by large industrial, general industrial and commercial users.

At the outset, cross-subsidisation protects vulnerable groups and reflects fairness. But in fact, it has long been criticised for deepening unfairness and most importantly distorting the electricity price. The use of cross-subsidy makes electricity prices unable to reflect the true cost of electricity supply and jeopardises the economic signals that electricity prices should provide. The result of cross-subsidy is neither fair nor efficient and the 2015 reform aims to gradually remove cross-subsidy in the electricity pricing. As commented by several interviewees, given the complex structure of cross-subsidy in any given province, diminishing its impact requires long term effort to understand the level of cross-subsidy, make it more transparent, and reduce the retail pricing for general industrial and commercial users.

Meanwhile, it seems that the reduction of electricity pricing in recent years is heading in this direction but removing cross-subsidies will inevitably lead to price increases, especially in the residential and agriculture sector, which brings not only economic but also some political considerations. It is also debatable whether complete removal of cross-subsidy is feasible in China's electricity pricing system, given the strong intervention by the provincial authority in managing and regulating the electricity sector, both on the side of supply and demand.

7 Assessing Electricity Markets and the Impact of ETS on Abatement

Due to different administrative powers, Hubei (as a province) and Shenzhen (as a municipal city) enjoy different levels of decision making in the areas of pricing, dispatch and investment. Moreover, different grid companies are in charge of the electricity network in Hubei and Shenzhen, namely the State Grid Corporation of China in Hubei and the China Southern Power Grid in Shenzhen. Different electricity market structures in Hubei and Shenzhen also influenced the progress of the market reform in both areas. At the initiative of the China Southern Power Grid, Shenzhen started the reform process on T&D tariff as early as 2014. Therefore, it has become one of the first localities to carry out re-assessment of T&D tariff after the official announcement of electricity reform in 2015. As a municipal city in Guangdong Province, Shenzhen's electricity market structure is also influenced by the overall market reform in Guangdong. In particular, Guangdong has made important progress towards establishing a provincial wholesale market. Hubei, on the other hand, has achieved relatively slow progress with the reform of its electricity market structure. Besides the complexity of transitioning from command and control to liberalisation in China, slow progress with reform in Hubei can be explained by the heavy reliance of the Hubei electricity sector on coal-fired electricity generation.

In this context, there is little evidence that the introduction of the ETS resulted in the internalisation of the carbon cost in the trading of electricity. Given that the electricity market regulation in Hubei was only adopted in May 2019, there is little information available on the empirical aspects of trading arrangements, such as wholesale pricing. The analysis of Shenzhen includes, where necessary, aspects of electricity market reform in Guangdong, taking into account that Shenzhen is part of Guangdong Province.

7.1 Pass-through of carbon cost to wholesale electricity market prices

Following the 2015 electricity market reform, it is possible for the carbon cost to be reflected in electricity market trading, at least in principle. Prices have partly been deregulated, with wholesale prices formed through negotiation and mutual agreement. However, in practice, the passthrough effect has been significantly limited for the following two reasons.

First, the small trading volume has limited the spill-over effect of benefits arising out of market trading. As a result of a reduction of the government benchmark prices, end consumers benefit from lower regulated electricity prices and therefore have less willingness to participate in market trading.

Second, the internalisation of carbon prices contradicts the political objective of reducing electricity prices. By aiming to avoid electricity price increases, the government can block the carbon cost. This explains the design choices made by the ETS pilot scheme in Shenzhen which covers indirect emissions to address the challenge of limited passthrough. Shenzhen relies on importing electricity from other parts of Guangdong Province and therefore enabling the carbon cost passthrough is dependent on electricity market reform in Guangdong. Although Guangdong initiated market trading of electricity before other provinces, the reform has yet to decouple the wholesale price from the government benchmark price.

7.2 Fuel switch: Impact of carbon price on dispatch

Unlike the deregulation of pricing, dispatch in Hubei and Guangdong is still largely managed on an administrative basis, in accordance with the rules in place before the 2015 reform.

In Guangdong, the interviewees indicate that the decision of system operators on dispatch is yet to be directly affected by wholesale market contracts. The current dispatch still follows the original rules, which are based on the operating hours allocated to each power plant. There are some potential changes made to the dispatch as the market transactions thrive. However, stability and security of the grid system is still the underlying force that resists the reform to the dispatch system.

Hubei requires the trading of electricity on the market but continues to adopt a system of administrative dispatch. In order to boost the trading volume, certain power plants that are managed by provincial dispatch are required to participate in market trading. The hydropower enterprises in the province that are subject to provincial dispatch shall participate in the market transaction with no less than 20% of electricity generated according to the generation plan (Hubei Provincial Energy Bureau, 2019). For thermal power plants, except for the electricity generation that is still managed under centrally or provincially managed dispatching with regulated pricing, all electricity generated is to be traded on the market. Thermal power units that have signed contracts with the Hubei Provincial People's Government with clear agreements on the calculation of electricity generation volume and price shall implement the contracts and agreements. The additional production outside the agreement shall participate in the electricity market transaction in full amount (ibid).

Green dispatching has also failed to achieve the desired outcome. In this regard, the dispatch policy proposed by the 2015 reform, which re-affirms priority dispatch of certain coal-fired power plants, is not aligned with the emission reduction and low-carbon investment objectives of the ETS. Carbon price signals and deregulated electricity prices are unlikely to influence the dispatching of power plants in the short term, given strong government intervention in the operation of the electricity sector in China.

7.3 Impact of carbon price on low carbon investment/(dis)investment

The overall decentralisation of permitting authority to approve new investment has largely enhanced the capacity of the provincial and municipal authorities to steer investments within their respective geographic boundary. Table 14 summarises the distribution of permitting authority between the State Council, the provincial authority and the municipal government on new investment in China's energy sector. It shows that the provincial governments have the most extensive authority in relation to the approval of new investments, particularly on the generation side. As elaborated above, the overall decentralisation of permitting authority from the NDRC to the provincial authorities was followed by a significant surge in new coal generation projects, leading to the overcapacity of coal-fired power plants. Under the existing dispatch system that is administratively managed, the surge of coal-fired power plants means more competition for dispatch with other cleaner sources of energy such as renewables, which exacerbates the renewable energy curtailment in China and is more likely to decelerate investments in renewable energy.

Despite the reform efforts to liberalise the market, the electricity sectors in Hubei and Shenzhen are still subject to strong government regulations. On the supply side, both localities have seen the rising consumption of coal in electricity generation despite contrasting generation and capacity mix. On one hand, it shows a common recognition that coal-fired generation plays an indispensable role to sustain electricity supply and ensure stability and security of the grid network. On the other hand, the experiences from Hubei and Shenzhen indicate that the role of carbon pricing is extremely limited in driving low-carbon investments. Following the transfer of decision-making powers from the government to the companies, energy companies in China have been actively participating in the development of investment proposals which are then subject to approval by government agencies. To date, there is little evidence that the cost of carbon has been considered when making such investment proposals in either Hubei or Shenzhen.

Free allowance allocation represents a key obstacle to the effectiveness of carbon pricing in driving low-carbon investments in China. Allowances have been allocated generously and for free to coal-fired power plants, limiting the compliance cost of the ETS for the industry. Both Hubei and Shenzhen tend to protect the coal power industry by providing sufficient – if not too many – allowances to coal-fired power plants, particularly in case of increase of coal prices. With generous allocation of free allowances in the Hubei and Shenzhen ETS, carbon prices have not had a significant impact on the operation cost of power plants and have not driven a reallocation of investments towards low-carbon energy.

Table 12: Permitting Authority for New Investment in the Energy Sector in China

Project		Approved by Competent Department under the State Council	Approved by Competent Department of Hubei Provincial Government	Approved by Competent Department of Municipal Government in Shenzhen
Hydropower Station	Total Installed Capacity of a Single Station Built on the Inter-provincial (regional and municipal) Rivers is 500,000 KW or above	√		
	Total Installed Capacity of a Single Station is more than 3 Million KW or more, or Projects Involving Relocation of 10,000 People or More	Approved by the State Council		
	The Total Installed Capacity of a Single Station Built on the Inter-provincial (regional, municipal), Inter-city (municipal) Rivers is 10,000 KW or more		√	
	Other Projects			√
Pumped Storage Power Station			√	
Thermal Power Station (including Captive Power Plant)	Coal and Gas Thermal Power Project		√	
	Biomass Power Generation Project		√	
	Projects Using by-product Heat, Pressure and Gas to Generate Electricity; Waste to Energy Project			√
Combined Heat and Power Plant (including Captive Power Plant)	Condensed Coal-fired Thermal Power Project		√	
	Gas-fired Thermal Power Projects with Single Unit Capacity of More Than 100,000 KW		√	
	Back-pressure Coal-fired Unit			√
	Biomass Power Generation			√

Project		Approved by Competent Department under the State Council	Approved by Competent Department of Hubei Provincial Government	Approved by Competent Department of Municipal Government in Shenzhen
Wind Power	Wind Power Projects with A Total Installed Capacity of 30,000 KW or More		√	
	Other Projects			√
Nuclear Power Plant		Approved by the State Council		
Power Grid Project	DC Line Projects of ±500 KV and above Involving Trans-Provincial (Regional and Municipal) Transmission; AC Line Projects of 500 KV, 750 KV and 1,000 KV involving Trans-Provincial (Regional and Municipal) Transmission	√		
	Of the above, DC projects of ±800 KV and Above and AC Projects of 1,000 KV	Recorded by the State Council		
	DC Projects of ±500 KV and Above; AC Projects of 500 KV, 750 KV and 1,000 kV not Involving Inter-Provincial (Regional or Municipal) Transmission		√	
	AC Project of 220 KV, Involving Cross-city AC Project of 110 KV		√	
	AC Project of 110 KV, not involving Cross-city transmission; and AC Project of 110 KV or Less			√

Source: Compiled by authors based on government official documents.

7.4 Demand reduction and pass-through of carbon cost to end consumer prices

Strong government regulation and cross-subsidisation of end-user electricity prices distort the price signals, including the carbon price signal, sent to end consumers in the Chinese electricity sector. This heavily regulated environment presents significant challenges to the role of the ETS in influencing emission reductions by end consumers. As the design of Shenzhen's ETS pilot suggests, an alternative solution to address the limited passthrough of carbon price is to cover indirect emissions by the ETS. The coverage of indirect emissions is needed in Shenzhen because electricity consumption by commercial buildings is significant and constantly on the rise. The lack of carbon price passthrough constrains the realisation of the ETS objective to drive low-carbon investment in sectors that produce emissions indirectly by using electricity produced through burning coal in another facility. In this regard, as commented by several interviewees, due to the regulated electricity pricing in China, covering indirect emissions provides a level playing field for sectors that lack incentives towards more efficient use of electricity.

Given the policy imperative of the central government to lower electricity prices, the cross-subsidy has been reduced nationwide, including in Hubei and Shenzhen. However, the current measure to reduce the level of cross-subsidies has only had a limited and temporary effect. In the long term, eliminating cross-subsidies is necessary to reflect the real cost of electricity generation – including the carbon cost – in the retail electricity price. Despite the objective of the 2015 reform to remove cross-subsidies over time, the implementation of this policy will take years to complete, given the complex structure of cross-subsidies and their deep integration in the provincial electricity pricing system. On a positive note, the gradual deregulation of on-grid tariffs, as well as wholesale and retail prices, provides a critical opportunity to understand the real cost of production in the electricity sector, as parties are free to negotiate the transaction price.

For the time being, government benchmark pricing continues to influence the price levels in the market trading of electricity – this is due to the recent adoption of market liberalisation and a low readiness of market participants to respond to price signals. It is reasonable to expect that as the effort of deregulation deepens and the volume of market trading increases, the difference between electricity market prices and government benchmark prices will become increasingly volatile. In addition, the market development to include not just monthly contracts but also a day-ahead market will also contribute to price discovery of electricity, which enables upstream generators to include carbon cost into their operation cost and pass the additional cost through to end consumers. The deregulation of electricity pricing in China provides the opportunity for the ETS to deliver its desired outcome.

8 Conclusions and Implications for the National System

Adopting an ETS in China is, in general, a positive development that can help address several problems that are related to China's decarbonisation efforts. As with any new regulatory instrument, design and implementation of an ETS in China faces significant challenges. The ETS pilot schemes in Hubei and Shenzhen provide some specific examples about how the effectiveness of carbon market regulation can be compromised by both political and economic considerations. For instance, several design choices made by the policy makers in Hubei and Shenzhen demonstrate that the pilot schemes are designed to test the operation of an ETS without hindering economic growth. This has been reflected in the design elements such as the ex-post adjustment mechanism which has been adopted both in Hubei and Shenzhen, as well as the complex process of cap setting in Shenzhen under an intensity-based target. In other words, the pilot schemes are steered to decelerate emissions growth and capping emissions through the carbon market carries a risk of being politically unacceptable.

A major lesson from the pilot schemes in Hubei and Shenzhen is that carbon market regulation needs to be carefully designed in order to deliver its desired outcome. The analysis on the impact of design features of carbon market regulation on carbon price in Hubei and Shenzhen indicate that the quality of the allowance price signal and the predictability are most affected by the lack of long-term target and the use of ex-post adjustment mechanism. In terms of the price volatility, allowance prices in Hubei have not demonstrated excessive volatility or high levels of intramonth volatility. Shenzhen's ETS pilot scheme experienced some significant price fluctuations at the early stage but the overall allowance prices in Shenzhen have not demonstrated excessive volatility thereafter. The price stabilization mechanisms in Hubei and Shenzhen are more for symbolic purposes due to the lack of implementation or details in the relevant rules. For the majority of regulated ETS entities in Shenzhen (i.e. in the manufacturing sector), the problem of information asymmetry between regulators and ETS entities creates large uncertainty regarding the supply of allowances. The lack of transparency increases the possibility of price volatility and unpredictability. The environmental effectiveness of the pilot ETS in Hubei and Shenzhen Pilot is difficult to assess and this difficulty results from the fact that the general lack of publicly available information on actual supply (actual number of allowances allocated for free and used CCERs) and demand (verified emissions) makes it difficult to analyse the impact of design features on the price signal or the interaction of carbon and electricity markets in both pilot schemes.

In this regard, the slow progress of the national ETS legislation has caused profound impacts on the development of China's national ETS. The ETS legislation is fundamental to all aspects of ETS operation and it explains why the national ETS has stalled. The announcement that the national ETS was established in December 2017 was a political statement more than a real commencement of the program. On the one hand, for industry, the major challenge is the uncertainty surrounding the national cap and allocation method because the detailed rules are not yet officially available—a central question that underlies their investment strategies towards low-carbon development.

On the other hand, the lack of national ETS legislation undermines the prospects of China's ETS pilots. Policy makers who are responsible for the ETS pilot schemes and the covered entities are still uncertain about the future of the pilot programs, which also partly explains their caution to impose stricter carbon market regulation. In addition, the boundaries of authority and responsibility for system design and market supervision must be defined as a priority. There are important coordination opportunities and challenges that have arisen as a result of these institutional changes that reshuffle the government agencies which affect progress of China's national ETS. Because more institutions are operating in the ETS space as China's ETS grows, more coordination is needed to ensure a robust legal framework governing the operation of China's ETS.

With respect to the impact of electricity sector regulation on the carbon market, the general feedback from the interviews indicates that electricity sector abatement induced by the carbon price depends on market structure and regulations and is extremely limited in Hubei and Shenzhen for the following reasons. First, the existing capacity mix in Hubei and Shenzhen impacts the role of carbon prices for the dispatching of power plants as well as for investment decisions. Hubei's generation is largely dominated by coal power and the administrative dispatch also favours coal power due to the underlying consideration of securing their investment return. Shenzhen's capacity mix relying mainly on gas generation implies a much lower short-term abatement potential than Hubei in the form of coal-to-gas fuel switching. Shenzhen also relies on importing electricity from other parts of Guangdong and thus, the impact of the carbon price through covering indirect emissions is rather small, unless the targets to reduce indirect emissions are set more stringently. Secondly, the limited passthrough is evidenced by the fact that electricity pricing in China is still subject to government regulation and neither the wholesale nor the retail electricity price is determined by including the carbon cost, thereby limiting the effectiveness of an ETS to steer the regulated entities to make low-carbon investments through price signals. The ETS pilot scheme in Shenzhen has covered indirect emissions to address the challenge of limited passthrough effect of carbon price, which is considered by the stakeholders as an important alternative and temporary solution. Thirdly, companion policies play a key role in determining the importance of carbon prices and investment decisions. In both Hubei and Shenzhen, strong companion policies have been implemented to reduce the energy – and thus carbon – intensity of power generation. Direct regulation co-exists with the pilot ETS, in order to achieve emission reductions, which decreases the role of carbon prices for the electricity sector. The strong government support for renewable energy development in Hubei and Shenzhen has also reduced the role of carbon prices for investment decisions. Finally, it should also be mentioned that the lack of data on power capacities and generation makes it difficult to analyse the power sector in general.

In the long run, there is a consensus among the interviewees that given the recent development of reducing electricity pricing, including the carbon cost through the administrative approach seems to be undesirable. Because of the limited scope for change through the administrative approach, electricity pricing in China needs to be flexible enough to reflect the carbon cost so that the carbon price signal can be better integrated into the operation of existing facilities and the decision-making for new investment. The gradual deregulation of the electricity market has generated important changes and indicated that the market can work differently than it has so far. Meanwhile, the reform has introduced more market participants in the trading of electricity and the provision of auxiliary services to end consumers, in particular in the industry sector. However, the general feedback from the interviews suggests that the reform process still has a long way to go in order to tackle some barriers to allow the market participants to respond to a carbon price signal appropriately. Since China's national ETS only covers the power sector during the initial phase, some reform measures are critical to ensure better performance of the national carbon market.

More specifically, the national ETS can benefit from the below lessons distilled from the analysis on Hubei and Shenzhen, with respect to the impact of carbon market regulation and electricity market regulation on carbon price signal.

On the carbon market design, design choices made by Hubei and Shenzhen suggest that ideally the national ETS should be designed to reduce the discretionary power held by the regulators, both at the central and provincial level, and government intervention in the market (e.g. pricing stability mechanisms) needs to be guided by clear rules. To reiterate some of the key findings: (a) the national cap will benefit from a binding and transparent cap on emissions, with clear medium- and long-term targets. A binding cap is fundamental to the functioning of the national ETS, by guiding market participants to respond to the carbon price signal. (b) For China's power sector, allowance allocation based on benchmarks provides the most certainty to market participants and the benchmark should be reasonably high to deliver a strong carbon price signal. (c) With respect to market infrastructure, Hubei Emissions Exchange and the Municipal Government of Shanghai have been nominated to design and construct the national registry and the trading platform, respectively. Both pilot schemes are better positioned than other pilot programs to leverage their resources and experiences to establish the relevant rules for registry and market oversight. (d) Based on the framework regulation for the national ETS, the linkage with CCERs will be made possible to allow flexibility for compliance and to drive investments into sectors that are most vulnerable to climate change. Finally, and most importantly, coordination is urgently required between the MEE and other central government agencies to allow trading of allowance derivatives and timely clearance of transactions on the trading platform, to allow better expression and communication of carbon price in the market.

Meanwhile, better performance of the ETS through a strong carbon price signal in China can hardly be expected without further reforms of the electricity market architecture, either through direct regulatory intervention aiming at reflecting the carbon cost into investment decisions, dispatching and end-user prices, or through further liberalisation of the electricity market. The 2015 reform is an important step towards further liberalisation, but the reform process has been slow, and the stakeholders have contrasting opinions about its future development. A major obstacle is that the policy framework underpinning the 2015 reform does not have any legally binding force and its implementation is not being closely monitored either. Among the reform measures, pricing deregulation has, to a certain extent, liberalised both the on-grid tariff and the wholesale and retail price of electricity, and thereby provided an essential level playing field to direct the electricity pricing system to be market-oriented. Importantly, as the pricing deregulation progresses, the market trading needs to proliferate by including the creation of a day-ahead market to facilitate better price discovery. In this regard, a province-based experimentation by deploying a day-ahead market is a sensible move forward, given that most provinces are still cautious about further liberalisation of the electricity market. With proliferation of market trading of electricity, the dispatch system needs to be adjusted to reduce administrative intervention. The dispatch reform is expected to be challenging, given that the past effort on green dispatch failed to achieve the desired outcome. Finally, and perhaps most importantly, the effectiveness of China's national ETS in internalising the carbon cost will also depend on the political acceptability of electricity price increases resulting from the strong carbon price signal.

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A Appendix

Monitoring, Reporting and Verification Rules in Hubei

Regulated entities under the Hubei ETS are required to formulate a carbon emissions monitoring plan each year, e.g. including the monitoring methods in place and the frequency of monitoring. The plan must be submitted to the competent authority in September each year. The regulated entities are required to strictly carry out monitoring according to the monitoring plan. If the monitoring plan changes, the entity shall report to the competent department in a timely manner.

In February each year, the regulated ETS entities in Hubei shall submit the carbon emissions report of the previous year to the ETS regulator. The ETS regulator in Hubei then entrusts third-party verification agencies to verify the carbon emissions of liable entities that are covered by the Hubei ETS ("Interim Measures on the Management", 2014, art. 34). The third-party verification agency shall independently, objectively and fairly verify the company's annual carbon emissions report, submit a verification report to the competent authority before the last working day in April each, and shall be responsible for the truthfulness and completeness of the report (ibid, art. 35). The third-party verification agency shall meet the following conditions:

a) having independent legal personality and a fixed business place;

b) having at least 8 professional and technical personnel qualified for verification; and

c) operating business related to greenhouse gas emission verification in the past 3 years (ibid, art. 36).

The competent authority shall conduct a random inspection of the verification reports submitted by third-party verification agency and inform them the results of inspection and examination (ibid, art. 38). The liable entities in Hubei are required to work together with third-party verification agency to verify and truthfully provide relevant data and information (ibid, art. 37). If there is any objection to the results of the examination, liable entity may submit a review application and provide relevant supporting materials to the competent authority within 5 working days after receiving the results of examination. The competent authority shall verify the application of review within 20 working days to decide (ibid, art. 39).

Sanction mechanisms for MRV in Hubei

If an entity fails to cooperate with a third-party verification agency to verify and truthfully provide relevant data and information resulting from the failure to conduct effective verification, the competent authority shall issue a warning and request the verification within a time limit. If the verification is not completed within the time limit, the allowances for next compliance period shall be halved according to the total allowances in the previous year (ibid, art. 48).

If a third-party verification agency fails to independently, objectively and fairly verify the annual carbon emissions of a liable entity, or submit a verification report to the competent authority, the competent authority shall issue a warning. If there is any illegal income, the illegal income shall be confiscated and a fine, less than 3 times of the illegal income but no more than 150,000 CNY, will be applied; if there is no illegal income, a fine of more than 10,000 CNY but less than 50,000 CNY shall be imposed (ibid, art. 50).

Penalty for non-compliance in Hubei

For liable entity that fails to formulate a carbon emission monitoring plan or submit the carbon emissions report on time, the competent authority shall issue a warning and require the entity to perform the reporting obligation within a time limit and may impose a fine of more than 10,000 CNY but less than 30,000 CNY (ibid, art. 47).

The ETS regulator in Hubei has established a blacklist system to include liable entities that have not fulfilled the obligation for compliance. The consequence is that the non-compliant entities are to be included into the relevant credit records within Hubei Province and the list of these entities is to be announced to the public through the government website and the news media (ibid, art. 43). If the liable entity is a SOE, the competent authority shall notify the state-owned assets supervision and administration agency at the provincial and/or central level (depends on whether the liable entity is a provincial or central SOEs). The state-owned assets supervision and administration agency shall incorporate the performance of liable entities into the appraisal and evaluation system for the SOEs (ibid, art. 44). For enterprises that fail to fulfil their obligation for compliance, the Hubei DRC shall refrain from accepting their applications for relevant national and provincial energy conservation and emission reduction projects (ibid, art. 45).

Monitoring, Reporting and Verification in Shenzhen

MRV guidelines and specifications

With regard to the development of MRV guidelines and specifications, the Shenzhen DRC has promulgated the Guidelines for Quantification and Reporting of Greenhouse Gases in Shenzhen and the Guidelines for Verification of Greenhouse Gas in Shenzhen, which specify the principles and requirements of GHG quantification, reporting and verification at the organisational level. Both Guidelines are local standards which have largely taken into account standards and procedures contained in the ISO 14064-1 (which specifies principles and requirements at the organisation level for quantification and reporting of GHG emissions and removals) and the Greenhouse Gas Protocol: Guidelines for Enterprise Accounting and Reporting, as well as the existing regulatory and institutional arrangements in Shenzhen. For the building sector, the Shenzhen government has issued the Guidelines for Quantification, Reporting, and Verification of Greenhouse Gas Emissions from Buildings which regulates the relevant practices in relation to MRV in this sector. Given that regulated ETS entities in Shenzhen are scattered across a wide range of industries, with a large number of small and medium-sized manufacturing enterprises that tend to have significant production fluctuations, the Shenzhen DRC does not require the ETS entities to prepare annual emissions monitoring plans.

Reporting content and frequency

With respect to the reporting content, in addition to the annual carbon emission report submitted by the ETS entities, industrial enterprises also need to submit reports on real production level and/or industrial added value. As to the reporting frequency, the ETS entities are required to submit a carbon emission report every quarter, as well as an annual report. Reporting the real production volume and/or industrial added value also needs to be conducted annually, through a separate report. In terms of reporting method, Shenzhen has established a GHG emission information management system which enables enterprises to submit both electronic and paper reporting.

Requirement for the verification agency

The third-party verification agency shall meet the following conditions, in order to provide verification services in Shenzhen:

1. having independent legal personality with proper registration in the city for more than two years;
2. having a fixed office space and necessary facilities in the city;
3. having more than ten full-time inspectors registered with the Municipal Market Supervision and Management Department, with at least two inspectors being engaged in verification service for more than three years;
4. having an organisational and internal management system that meets the requirements for verification work;
5. having relevant work experience in quantifying and verifying greenhouse gas emissions, with no record of violations of relevant laws or regulations;
6. having certain financial solvency and set up a fund to deal with risks or purchased corresponding risk liability insurance ("Interim Measures for the Administration", 2014, art. 31).

Key timeline for MRV

The liable entity shall compile an annual carbon emission report based on emission quantification and reporting standards and then submit it to the Shenzhen DRC through the GHG emission information management system before 31 March each year (ibid, art. 28). This deadline also applies to eligible enterprises which are required to surrender an annual report on real production volume and/or industrial added value to the Municipal Bureau of Statistics. After submitting the annual carbon emission report, liable entity shall entrust a verification agency to verify the carbon emission report and submit the verification report to the Shenzhen DRC before 30 April each year (ibid, art. 29). Once the report on real production and/or industrial added value is approved by the Municipal Bureau of Statistics, liable entity needs to submit the report to Shenzhen DRC before 10 May each year. The liable entity shall not entrust the same verification agency or the same inspector for verification for three consecutive years (ibid, art. 30). The competent authority shall conduct a random sample inspection of verification reports submitted by third-party verification agency, and in principle, the proportion of sample checks shall not be less than 10% of the total number of reports (ibid, art. 34).

Penalties for non-compliance in Shenzhen

The ETS regulation in Shenzhen, known as the *Regulations of Carbon Emission Management of Shenzhen Special Economic Zone*, was adopted by the Shenzhen Municipal People's Congress as a local regulation on 30 October 2012. This was the first ETS regulation officially recognised under China's legislative framework. For several interviewees, the fact that this local regulation was adopted before the commencement of the ETS pilot in the following year is essential for the integrity of the ETS, as it provides the legal foundation upon which the enforcement of penalties for non-compliance is possible. As required by China's Legislation Law, local administrative organs do not have the authority to enforce penalty provisions unless authorised by law and regulations. By providing a regulatory basis for penalties, the Shenzhen ETS regulation is generally regarded as one of the most significant efforts by local governments towards mitigating climate change. The Regulations of Carbon Emission Management of Shenzhen Special Economic Zone is supported and supplemented by the *Interim Measures for the Administration of Carbon Emissions Trading in Shenzhen*, particularly on penalty provisions. Together these two regulatory documents have established the regulatory framework governing the operation of the ETS pilot. As indicated by the interviewees, the regulatory framework governing the Shenzhen ETS has two main characteristics. First, the Shenzhen ETS provides for the extensive penalty provisions against illegal activities and conducts by all the stakeholders. Second, the level of penalty for non-compliance by regulated entities in the Shenzhen ETS is more severe, in comparison to the other ETS pilots. However, the regulatory framework governing the Shenzhen ETS also grants the regulators broad discretionary authority to issue fines (within certain limits). This arrangement raises concerns as to whether the penalty provisions in practice can provide effective deterrence. The illegal activities and conducts regulated by the Regulations and Interim Measures and the punishments are tabulated as below.

Table 13: Illegal Activity and Conduct and Penalty Provisions under Shenzhen ETS Pilot Scheme

Regulated Entity and Agency	Illegal Activity and Conduct	Penalty
Liable entity	Fail to surrender sufficient allowances on time	Mandatory deduction of allowances from the immediate round of allocation and impose a fine equal to three times of average allowances price in past 6 months
	Fabricate relevant data	Correction within certain time limit and fine
	Collusion with verification agency to fabricate data	Correction within certain time limit and fine
Third-party verification agency	Collusion with liable entity to fabricate data	Correction within certain time limit and fine
	Issue false report or serious misrepresentation in the report	Correction within certain time limit, fine and compensation for losses
	Violate principle of fair competition	Correction within certain time limit and impose a fine between 50,000-100,000 CNY
	Leak relevant data and breach confidentiality agreement	Correction within certain time limit, impose a fine between 50,000-100,000 CNY and compensation for losses
Party participating in trading	Illegal transaction	Correction within certain time limit and impose a fine between 50,000-100,000 CNY
Emission Trading Exchange	Inaction or failure to perform duties	Correction within certain time limit and impose a fine between 50,000-100,000 CNY
Regulatory agency	Negligence, abuse of authority, or malpractice for personal gains	Administrative sanctions, compensation for damages, and criminal sanction (if criminal law is triggered)

Source: Interim Measures for the Administration of Carbon Emissions Trading in Shenzhen, 2014.