Evaluating Regional Emissions Trading Pilot Schemes in China's Two Provinces and Five Cities

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Abstract

With the highest energy use and greenhouse gas emissions around the world, China has begun to adopt comprehensive approaches to control its CO_2 emissions and fight climate change. China has committed to reduce its carbon intensity by 40% to 45% compared to 2005 levels by 2020. In 2011, China initiated the development of seven regional carbon trading scheme (ETS) pilots in two provinces (Guangdong and Hubei) and five cities (Beijing, Tianjin, Shanghai, Chongqing and Shenzhen) and has embarked on an ambitious pathway for establishing a national carbon market in 2017. This paper provides an overview and analysis of China's carbon emission trading market. A background and design characters of China's seven ETS pilots are introduced. Market performance and compliance are summarized. Linkage existed in China's carbon emission trading market is identified.

Keywords: China, emissions trading schemes, performance

1. Introduction

Reducing the anthropogenic emissions of greenhouse gases (GHGs) linked to climate change is a major challenge for international governance. China surpassed the United States and has been the world's largest emitter of CO_2 since 2006. In 2013, China accounted for 22.4% of the world's energy consumption, and 27.1% of global energy-related CO_2 emissions (BP Statistical Review of World Energy, 2014). China's carbon emissions rose by more than 140% from 2001 to 2013. Table 1 shows China's energy use, carbon emission from energy consumption and GDP.

According to BP Statistical Review of World Energy 2013, 43.5% of global CO_2 emissions in 2012 came from two countries: the United States and China. While the emissions from the US are declining due to its economic setbacks, the emissions from China, however, are still growing at a pace. China has thus become the focus of attention on climate change around the world.

Table 1. China's energy use, CO_2 emissions and GDP (2005-2013)

	Annual growth (%)	Index (2005=1) at 2013
GDP	10.1	2.16
Energy	6.0	1.59
CO_2	5.4	1.52
Energy/GDP	-3.8	0.74
CO_2/Energy	-0.5	0.96
CO_2/GDP	-4.3	0.71

Sources: International Energy Agency (IEA) (2013) for 2005-2011 data; Teng and Jotzo (2014) for 2012-2013 data.

China's per capita CO_2 emissions grew rapidly from 2.1 t in 1990 to 7.2 t in 2013, while in 2013 EU's per capita CO_2 emissions is 6.8 t. China's energy intensity dropped 26.7% from 2004 to 2013, as shown in Figure 1.

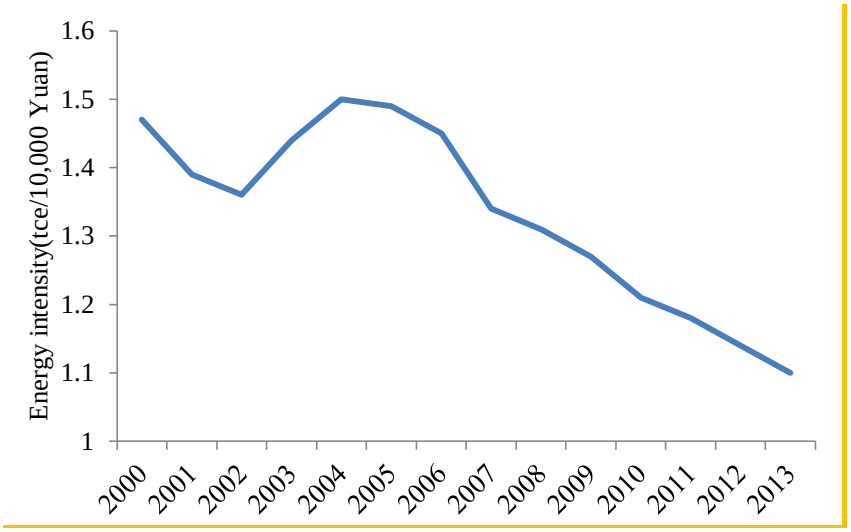


Figure 1. Development of China's energy intensity (2000-2013)

Sources: China Statistics Year book 2013, 2014
Note: "tce" is ton of coal equivalent.

The emission growth is largely the result of China's rapid economic development. Although China has experienced several decades of remarkable economic growth, its GDP per capita and CO_2 emissions per capita are still significantly lower than in the developed countries (Figure 2) (CAIT, 2014).

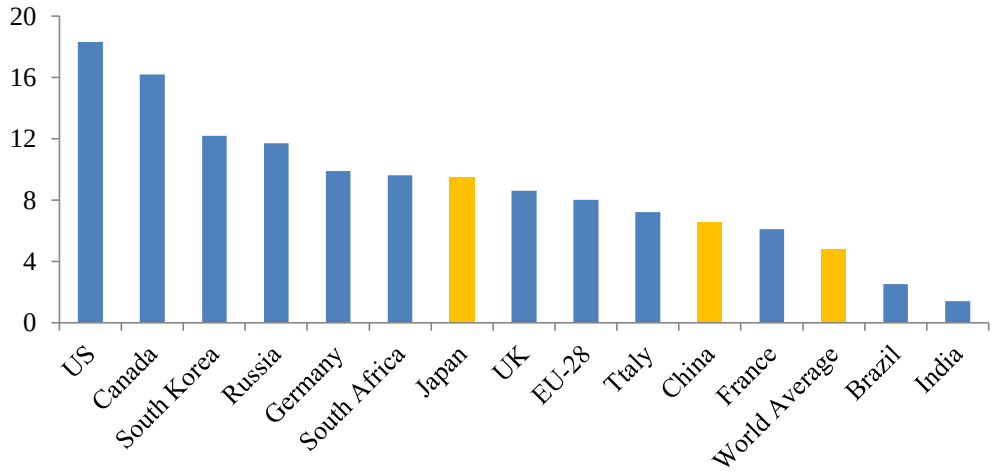


Figure 2. Global comparisons of per capita CO_2 emissions in 2010 (ton)

Source: CAIT (2014).

By comparing energy intensities around the world, it is found that for China as a whole, there is still considerable room for further improvement. As shown in Figure 3 (IEA, 2013), China's energy intensity in 2011 was 658 toe/million USD, which was about 3.6 times that in the US and 5.7 times that in Japan.

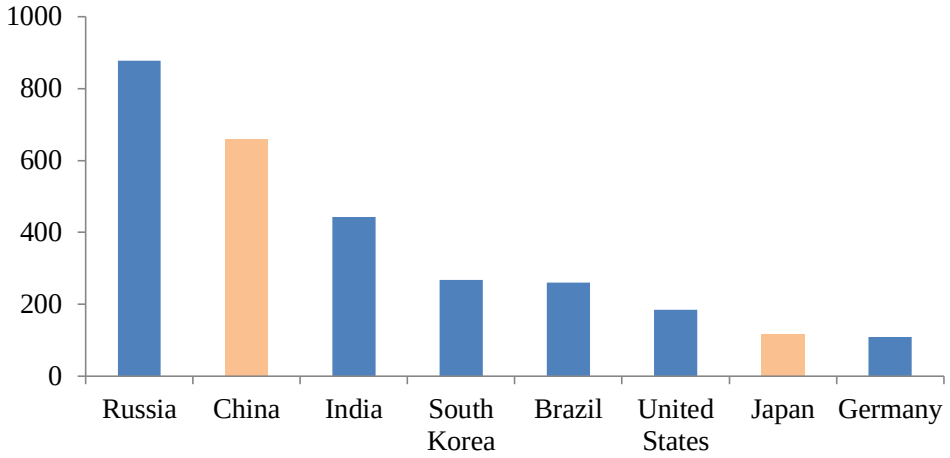


Figure 3. International comparison of energy intensity in 2011 (toe/million USD)

Source: IEA (2013).

With the highest energy use and greenhouse gas emissions around the world, China has begun to adopt comprehensive approaches to control its CO_2 emissions and fight climate change. In China, administrative bodies developing mechanisms to fight climate change include the National Development and Reform Commission (NDRC), the

National Leading Group to Address Climate Change, various ministries, and representatives of localities and sectors. China's climate change policy system is based on *China's National Climate Change Program* and *The Outline of the Twelfth Five-Year Plan for National Economic and Social Development* (FYP 12), which covers 2011-2015, and special plans and work programs within various sectors and localities support these policies. In addition, the 2009 Resolution of the Standing Committee of the National People's Congress, *Making Active Response to Climate Change*, requires that the government's work plan integrate enacted climate change related laws.

China has committed to reduce its carbon intensity, i.e. CO_2 emissions per unit of gross domestic product (GDP), by 40% to 45% compared to 2005 levels by 2020 and to increase the ratio of non-fossil energy to the consumption of primary energy to 15% (NDRC, 2010). At present, China does not have a mandatory national emissions trading system. However, the country does have experience with climate change-related market mechanisms, including voluntary emissions trading and development of pilot emission trading scheme at province and city levels. Table 2 provides an overview of developments in China's carbon policy, with emphasis on those paving the way for an Emissions Trading Scheme (ETS).

At the end of 2011, the Chinese government announced its intent to establish a domestic emissions trading system, which is more cost-effective and internationally compatible for emission reduction. China's FYP 12 sets forth the aim to reduce CO_2 per unit of GDP by 17% from 2011 to 2015, and it lays out plans to "gradually develop a carbon trading market." In 2011, China initiated the development of seven regional carbon trading scheme pilots in two provinces (Guangdong and Hubei) and five cities (Beijing, Tianjin, Shanghai, Chongqing and Shenzhen). The seven ETS pilots are required to be established before the end of 2013 and fully initiate trading by the end of 2015. A national ETS is expected to be established in 2017 and will depend to a large extent on the experiences gained in the seven pilot schemes.

The seven pilot schemes represent a relatively large geographic distribution (as shown in Figure 4), cover geographic area exceeding 481 thousand square kilometers (5% of China's total land mass), population of over 260 million people (around 19% of China's population) and GDP of almost 1.8 trillion dollars in 2010 (33% of China's

GDP) (Zhang et.al, 2013) while covering 20% of China's energy use and 16% of China's carbon dioxide emissions. The two pilot areas with the greatest population and land mass are Guangdong (104 million people, 177,900 km^2) and Hubei (58 million people, 185,900 km^2). Following them are Beijing (20 million people, 16,801 km^2), Shenzhen (13 million people, 1,953 km^2), and Shanghai (23 million people, 6,340 km^2). With estimated 240 million vehicles on the road in 2012, China is the world's largest automobile market sources. About 24 million (10% of China's total) were on the road in the pilot regions.

Table 2. Developments in China's ETS design in the context of carbon policy

Time	Policy
Dec. 2009	Commitment to reduce national emission intensity by 40%-45% in 2020 compared to 2005 level.
Aug. 2010	NDRC designated low carbon development areas in eight cities and five provinces, and carbon trading is encouraged as part of the overall development strategy.
Oct, 2010	State Council mentioned plans to establish an ETS.
Nov, 2010	China's 12th five year plan proposed an ETS as a central part of China's energy and climate policy.
Nov, 2011	NDRC officially approved seven carbon trading pilots schemes.
Dec, 2011	The State Council further clarified steps to establish an ETS during the 12th FYP.
June, 2012	NDRC set interim measures to support voluntary carbon emission reduction and indicates that Chinese Certified Emission Reduction can be used as offsets in the ETS pilots.
2012-2013	Design phase for ETS pilots, which includes allocation methods, approval, and detailed implementation plans for each pilot.
2014	Operational phase for ETS pilots, with the goal to establish a national ETS after 2016.

Sources: Xinhua net (2009); State Council (2010a, 2010b, 2011); NDRC (2011, 2012).

These seven pilot jurisdictions represent cumulative emissions of 1.5 billion tons of CO_2 (2010 data). They are all located in relatively highly developed regions with low emissions intensity compared to the national average level, and per-capita GDP is higher than national average level. Most of the seven ETS pilots were previously selected as low-carbon development pilot areas (NDRC, 2010). They differ in terms of

economic scale, GDP per capita, and emissions intensity. In terms of industrial structure, the pilots have a large share of secondary industry, which is essentially heavy industries, account for share of 55% in total GDP. Hubei is a relatively less developed region with an economic structure dominated by heavy industry, while the economies of Shanghai, Beijing and Shenzhen are dominated by services and some manufacturing (Figure 5, Figure 6). In order to increase the percentage of emissions covered by the ETS, both Beijing and Shenzhen have required key companies in the service sector to join the scheme. As to the carbon intensity, most of seven ETS pilots are relatively lower than the national average.

Figure 4. Location of seven ETS pilots in China

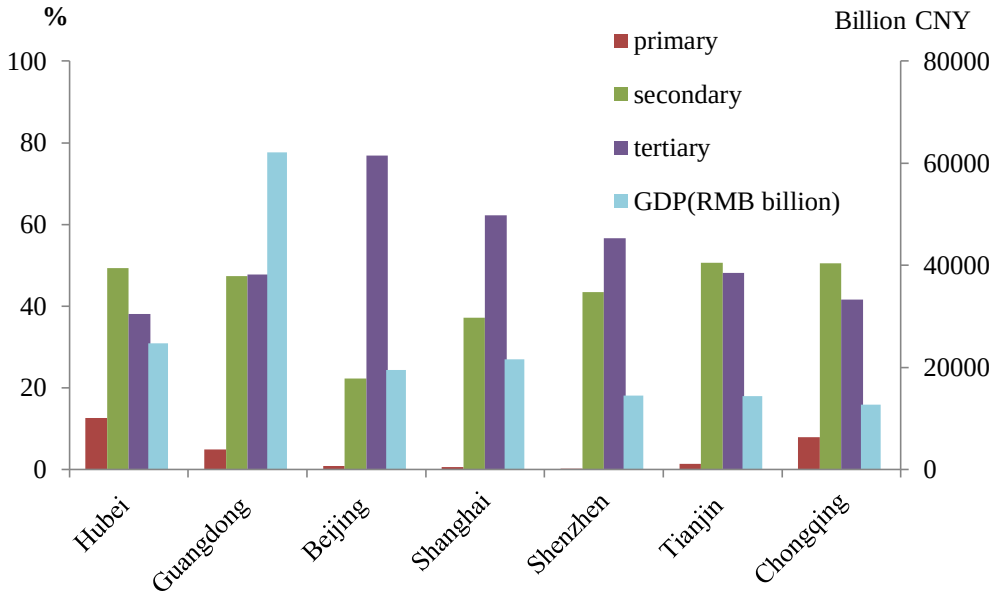


Figure 5. Comparison of economic development in seven pilot regions (2013)

Sources: China Statistics Year book (2014); China Energy Statistics Year book (2014)
Notes: Bars under primary, secondary and tertiary indicate their shares (%) while bars under GDP are shown in RMB billion.

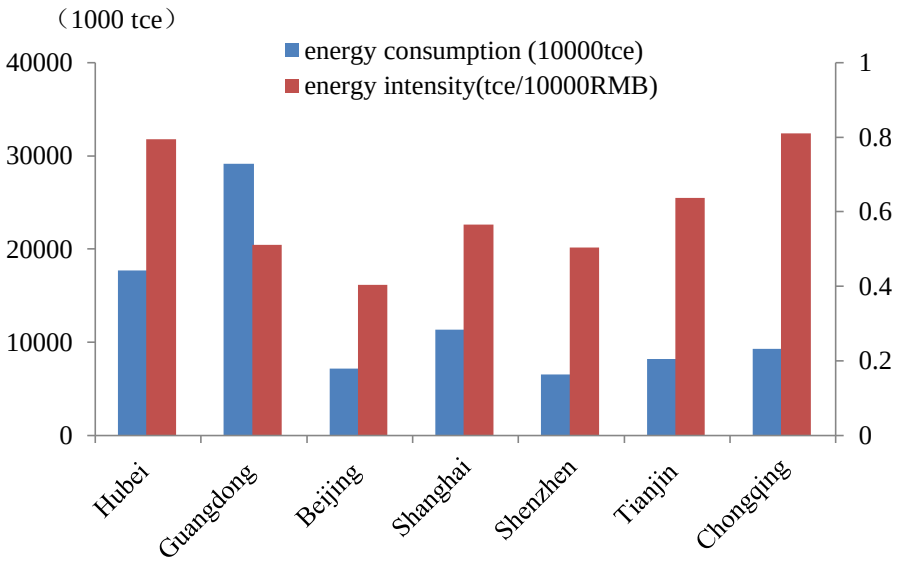


Figure 6. Comparison of energy consumption in pilot regions

Sources: China Statistics Year book (2013); China Energy Statistics Year book (2013)
Note: “tce” is ton of coal equivalent.

Basic information on seven ETS pilots is summarized in Table 3.

Table 3. Basic information of seven ETS pilots

Indicator	China	Hubei	Guangdong	Beijing	Shanghai	Shenzhen	Tianjin	Chongqing
Administration level	Nation	Province	Province	Municipality	Municipality	Municipality	Municipality	Municipality
GDP(CNY billion)	568,854	24,669	62,164	19,501	21,602	14,500	14,370	12,657
GDP growth rate (%)	7.7	10.1	8.5	7.7	7.7	10.5	12.5	12.3
GDP per capita(CNY1000'S)	41.8	42.4	58.4	92.2	89.4	58.9	97.6	42.8
Industrial structure (primary: secondary: tertiary)	10:43.9:46.1	12.6:49.3:38.1	4.9:47.3:47.8	0.8:22.3:76.9	0.6:37.2:62.2	0.04:43.4:56.6	1.3:50.6:48.1	7.9:50.5:41.6
Industrial value added (billion Yuan)	210,689	11,160	27,426	3,537	7,237	5,695	6,679	5,250
Fixed-asset investment(billion Yuan	447.074	20,178	22,859	7,032	5,648	2,501	10,121	11,205
Fixed-asset investment growth rate (%)	19.3	25.8	18.3	8.8	7.5	14.0	14.1	19.5
Urbanization rate(urban/total population)	53.7	54.5	67.8	86.3	-	-	-	58.3
Energy consumption(10,000 tce)	341,094*	17,675*	29,144*	7,178*	11,362*	6,525*	8,208*	9,278*
Energy structure(proportion of coal in primary energy, %)	70.6*	75.0*	48.0*	29.5*	41.8*	-	51.4*	67.4*
CO_2 intensity target 2015 compared to 2010	-17.0%	-17.0%	-19.5%	-18.0%	-19.0%	-21.0%	-19.0%	-17.0%

Resources: "Statistical Bulletin for National Economic and Social Development", "China Energy Statistics Year book."
Notes: 1. Most numbers in the table are2013 data; "*" indicates 2012 data. 2. "tce" is ton of coal equivalent.
3. "-" indicates that the data of the indicator could not be accessed in any official statistic publication.

2. Design Details of China ETS

All seven ETS pilots have now completed their implementation plans (design phase) and begun operations (operational phase). The Shenzhen ETS was the first to begin operations in June 2013, followed by Shanghai and Beijing in November, Guangdong and Tianjin in December, then Hubei in April 2014, and lastly Chongqing in June 2014. The pilots are intended to reduce the carbon intensity of their respective regions, with all setting their intensity reduction targets to somewhere between 17% and 21%.

2.1. Legal frameworks

The seven ETS pilots generally are based on provincial and municipal administrative rules as their main legal enforcement, and complemented by some technical standards and implementation regulations. All the seven pilots have published their ETS Implementation Plans (Table 4), and some pilots have released Carbon Emission Allowance Allocation Plans and ETS Pilot Management Methods.

Table 4. Development of seven ETS pilots

	Time	Milestones
Guangdong	2012.05.28	Call for carbon emission trading professional services in Guangdong
	2012.09.07	Guangdong Working Plan for Emissions Trading Guidelines Guangdong Work Schedule in Carbon Emission Trading Pilot
	2013.01.16	Guangzhou Emissions Exchange filed in NDRC
	2013.02.27	The Training of Historical Carbon Emissions Reports for Key Enterprises
	2013.07.04	Guangdong Draft Measures on Emissions Trading Pilot
	2013.11.25	Guangdong Initial Allowance Allocation and Working Plan on Emissions Trading Pilot (Interim) The list of enterprises under the cap and enterprises with new projects
	2013.12.18	Carbon Emissions Trading Rules of China Emissions Exchange Interim Management of Memberships of China Emissions Exchange
Hubei	2012.12.10	Hubei Working Plan for GHG Emission under the12th Five-Year Plan
	2013.02.18	Hubei's Working Plan for emissions trading pilot
	2013.04.16	Agreement to establish the Hubei Carbon Emissions Exchange
	2013.08.19	Hubei Draft Measures on Emissions Trading Pilot

Shanghai	2012.07.03	Shanghai Working Plan for Emissions Trading Guidelines
	2012.11.20	The Initial List of Enterprises under the Shanghai Emissions Trading Pilot
	2012.12.11	Notice on the Initial Report of Inventory Work in Shanghai Emissions Trading Pilot Guidance for Accounting and Reporting of the GHG Emissions in Shanghai (Interim)
	2013.02.21	Notice on the 2012 Carbon Emissions Report Work in Shanghai Emissions Trading Pilot
	2013.04.17	2013 Working Plan of Energy Conservation and Climate Change in Shanghai
	2013.11.18	Shanghai Interim Measures on Emissions Trading Pilot
	2013.11.22	Shanghai Carbon Emissions Allowance Allocation and Management Plan in 2013-2015 Temporary Provisions of Carbon Emissions Allowance Registration Management in Shanghai
	2013.11.25	Notice on the Standard of Transaction Fee in Shanghai Notice on the Standard of Membership fee in Shanghai Carbon Emissions Trading Rules of Shanghai Environment Energy Exchange Shanghai Management on Carbon Emissions Trading Risk Control Management on Membership of Shanghai Environment Energy Exchange Settlement of Carbon Emissions Trading Rules of Shanghai Environment Energy Exchange Shanghai Environmental Energy Exchange Emissions Trading Violations Default Processing Approach Management on Carbon Emissions Trading Information of Shanghai Environment and Energy Exchange
Tianjin	2013.02.05	Tianjin's Working Plan for emissions trading guidelines
	2013.12.20	Tianjin Interim Measures on Emissions Trading Pilot
	2013.12.24	Tianjin Development and Reform Commission Notice on Carbon Emissions Trading Work in Beijing
	2013. 12.25	Notice on the Standard of Transaction Fee in Tianjin Carbon Emissions Trading Rules of Tianjin Climate Exchange (Interim) Settlement of Carbon Emissions Trading Rules of Tianjin Climate Exchange (Interim) Management on Carbon Emissions Trading Risk Control in Tianjin Climate Exchange (Interim)
Shenzhen	2012.09.10	Shenzhen Draft Decision on Strengthening the Management of Carbon Emissions
	2012.09.20	The initial verification on carbon emissions in Shenzhen authorized by Shenzhen Market Administration
	2012.10.25	Client Operation Manual of Emissions Trading System
	2012.10.30	Provisions of Carbon Emissions Management of the Shenzhen

		Special Economic Zone
	2012.11.06	Specification with Guidance for Quantification and Reporting of the Organization's GHG Emissions
	2012.11.07	Specification with Guidance for Verification of the Organization's GHG Emission
	2013.01.20	The Limits of Pubic Building Energy Consumption in Shenzhen
	2013.04.20	Specification with Guideline for Quantification and Reporting of Building GHG Emission Specification with Guidance for Verification of Building GHG Emission
	2013.03.08	Shenzhen Standard of Transaction Fee on Emissions Trading Pilot
	2013.05	Involved Companies Operational Manual of Shenzhen Emissions Trading Registry Management Rules on Membership of Shenzhen Emissions Exchange
	2013.06.13	Membership Structure of Shenzhen Emissions Exchange Spot Transaction Rules for Shenzhen Carbon Trading(Interim) Trading Guidelines of Shenzhen Emissions Exchange(Interim)
	2013.10.29	Shenzhen Draft Measures on Emissions Trading Pilot
Beijing	2011.08	Beijing 12th Five-Year Plan on Saving Energy and Climate Change
	2013.11.20	Notice on Carbon Emissions Trading Work in Beijing Beijing Carbon Emissions Accounting and Reporting Guidelines(2013) Beijing's Carbon Emissions Trading Verification Institutions Management Approach (Trial) Beijing's Carbon Emissions Trading Verification Approach (Trial) Beijing's Carbon Emissions Trading Registration System Operational Guidelines Beijing's Procedures of Reporting GHG Emissions Beijing's Information on Opening Carbon Emissions Trading Account
	2013.11.22	OTC Rules for Beijing Carbon Trading
	2013.11.25	Carbon Emissions Trading Rules of Beijing Environment Exchange
	2013.11.27	Notice on the Standard of Transaction Fee in Beijing
Chongqing	2011.04.27	Chongqing's Carbon ETS Establishment Work Plan and Division of Tasks
	2012.09.08	Chongqing ETS pilot based on Chongqing Draft Rules for Emissions Trading Guidelines
	2013.01.24	Chongqing's Emissions Trading Platform and Registry Construction Project
	2013.04.24	Launch to Establish pilot ETS

Source: Collected and collated by the author.

2.2. Coverage

All seven pilot schemes cover both direct and indirect emissions. Direct emissions refer to emissions generated in the covered area, while indirect emissions are emissions outside the area but linked to the use of goods in the covered area. For instance, emissions attributable to electricity actives can be considered as indirect emission. Actually, indirect emission accounts for a large share of total emission covered.

An ETS should establish thresholds that are applied to determine which enterprises are included in the ETS. Such thresholds may be expressed in terms of carbon emissions that are emitted or size. The EU ETS has sector-specific thresholds. As shown in Table 5, the seven pilots have emissions thresholds. The thresholds and total number for coverage vary greatly between different pilots, with Hubei having the highest threshold of 60,000 tCO_2 per year, and Shenzhen with the lowest threshold of 5,000 tCO_2, while in EU, the new emitter's threshold is 25,000 tCO_2 (the new emitter). A higher threshold means only a smaller number of entities covered in the scheme, for instance, there are only 114 covered installations in Tianjin, while 832 in Shenzhen (Table 5), Shenzhen ETS covers 635 industrial enterprises from 26 sectors and 197 public buildings, accounting for 26% of GDP and 38% of carbon emission in 2010. This variation is due to the emission threshold used to determine coverage, local composition of industry, and the size of the covered area. The seven pilots all include the following sectors: heat and electricity production, iron and steel, nonferrous metals, petrochemicals and chemicals, paper, cement. However, there are also some differences across different pilots. For instance, Shenzhen has implemented the broadest coverage of emissions, including all direct and indirect emissions from all industrial sectors, as well as buildings sector. Hubei meanwhile is the world's third largest emissions trading scheme (Qi et.al, 2014). Heavy industries including refining and cement, steel, chemicals, along with power generation, dominate the province's economy and the trading scheme. In Tianjin, the oil and gas exploration sector is also included.

As shown in Table 5, collective CO_2 emissions in the seven pilots exceed 2.4 billion tons, and they have a cumulative cap of 1.247 billion tons including more than 2,000 enterprises. The largest is Guangdong with a first year cap of 388 million tons of CO_2 and 242 enterprises, while Shenzhen has the smallest cap with 33 million tons of CO_2. In total, about 53% of the total CO_2 emissions of these jurisdictions are

included in the first year of the pilots. The seven pilots have ETS-wide absolute caps. Policymakers in these programs have affirmed that additional allowances will not be introduced into the system, regardless of economic growth rates and/or whether emissions exceed the initial cap.

For the pilot, broader coverage will lead stronger incentive to reduce overall emission, but the increasing number of entities will also aggravate compliance cost to industry. Moreover, differences of threshold and the number of covered entities among different pilots will make a uniform national ETS more complicate. For instance, Hubei province has the highest threshold of 60,000 tCO_2 per year, while Shenzhen with the lowest threshold of 5,000 tCO_2. The enterprises that emit less than 60,000 tCO_2 will not be included in Hubei province, and covered sectors vary between different pilots.

Table 5. Coverage in seven ETS pilots

Pilots	Covered sectors	Threshold	Covered entities	Annual cap (million tons)	Covered emission (%)
Guangdong	Power, cement, iron and steel, ceramic, petrochemical, textile, non-ferrous metals, plastics, and paper	20,000 tons	184	388	50%
Shanghai	Industrial sectors (iron and steel, power, textile, rubber, materials, petrochemical, chemical, non-ferrous metals, etc.)	20,000 tons	191	160	57%
	Non-industrial sectors (airlines, airports, ports, hotels, etc.)	10,000 tons			
Tianjin	Iron and steel, chemical, power, heating, petrochemical and exploitation and those of civil buildings	20,000 tons	114	160	60%
Beijing	Power, heat supply, cement, petrochemical, other industrial sectors, service	10,000 tons	415	78	49%
Shenzhen	Industrial sectors (26 sectors such as power, manufacturing, etc.);	5,000 tons	635	33	54%

	Building	10000/20000 square meters	197		
Hubei	Power, Steel, Petrochemical, Cement, Auto production, Nonferrous metal, Glass, Paper, etc.	60,000 tons	138	324	35%
Chongqing	Iron and steel, power, textile, rubber, etc.	20,000 tons	242	130	35%-40%

Sources: SinoCarbon Innovation& Investment Co., Ltd; China carbon market report, 2014; ICAP (2014); Zhang et al. (2014); Guangdong DRC (2014 a, b).

Enterprises representing at least 32 different sectors are included in China's seven carbon trading pilots. With representatives from about 26 different sectors, Shenzhen may have the most diverse ETS. At the opposite extreme, Guangdong focuses on four sectors-cement, electricity generation, iron and steel, and petrochemicals (Table 6).

Table 6. Sectors included in seven ETS pilots

Sector	Shenzhen (26)	Shanghai (18)	Beijing (32)	Guangdong (4)	Tianjin (6)	Hubei (8)	Chongqing (7)
Aluminum							▲
Auto production			▲			▲	
Aviation (ground equipment)		▲					
Buildings	△		▲	△			
Buildings materials		▲					
Calcium carbide							▲
Caustic soda Buildings			▲	△			▲
Cement			▲	▲		▲	▲
Ceramics			▲	△			
Chemical fibers	▲	▲					
Chemicals	▲	▲	▲		▲	▲	▲
Commerce		▲	▲				
Electricity	▲	▲	▲	▲	▲	▲	▲
Food production	▲		▲				
Ferroalloy							▲

Finance		▲	▲				
Glass	▲		▲			▲	
Heat supply		▲	▲		▲		
Hotel		▲	▲				
Iron & steel		▲		▲	▲	▲	▲
Nonferrous metals		▲		△		▲	
Oil & gas					▲		
Paper	▲	▲	▲	△		▲	
Petrochemicals		▲	▲	▲	▲		
Plastics	▲		▲	△			
Port		▲					
Printing	▲						
Railway		▲					
Rubber	▲	▲	▲				
Service			▲				
Telecommunication	▲		▲				
Textile	▲	▲	▲	△			
Thermal power	▲		▲				
Transportation	△			△			
Water supply	▲						

Source: Emissions Trading Lessons from Carbon Trading Pilots in China, 2014. http://www.cciced.net/ztbd/nh/2014/wybg/201412/P020141201318189474825.pdf

Notes: ▲: Included in year one. △: May be included in future years (post year one).

2.3. Allocation

The cap (total amount of permits issued) is an important aspect of ETS. The cap varies across different pilots. The total allocation of the seven pilots combined is 1.2 billion tons of carbon emission, which account for 7% of China's total carbon emission. Pilot ETS coverage ranges from 33% of emission in Hubei to 60% of emission in Tianjin. Guangdong ETS, the largest of the Chinese ETS pilots, itself covers 388 $MtCO_2$ in 2013, which is similar to the size of France's emissions in 2012.

Setting allowance is an important issue in the ETS process. Allowance allocations in the seven pilot ETS are based on the local targets from the 12th FYP. Guangdong

and Shanghai clearly point out that they will assign annual carbon emission allowances for the period of 2013-2015 at once. In China's ETS pilots almost all the permits are allocated at no cost, while Shenzhen, Shanghai and Guangdong are developing the use of auction. One rationale reason for free allocation is that it will reduce the burden to the entities and thus has less negative impact on economic development, which is still a priority for local governments.

Allocation methodologies vary among Chinese ETS pilots, even within the same sectors. While the allocation to covered enterprises is primarily based on the historical emissions data, and the allocation to new entrants is based on benchmarks or expected emissions of the planned new capacity. Also the reference period is different. Shanghai takes the data of 2009-2011 into consideration, while Guangdong uses the data of 2010-2012 as the reference. Table 7 summarizes the allocation approaches of China's seven pilot regions. (Please refer to Table 9 for the details on the allowance allocation of seven ETS pilots.)

Table 7. Allowance allocation of seven ETS pilots

Pilot	Allocation period	Allowance allocation	Reserve
Guangdong	For the whole phase	Based on historical industrial emissions, allowance allocation for free	3% of total allowances are for new entrants in 2013-2014; 10% of total allowances are for new entrants in 2015
Shanghai	Annually	Allocation based on historical emissions, baseline based allocation approach, allocation for free or against a charge	No reserve
Tianjin	For the whole phase	Based on industrial emissions, mainly issued for free with partial allowances against a charge	Not published
Beijing	Annually	Manufacturing, other industrial and service industries should receive allowances based on historical emissions; power and electricity industries in accordance with the historical carbon intensity.	Not published
Shenzhen	Annually	Based on historical industrial emissions, allocation for free or against a charge. Free allowances cannot be lower than	2%

		90%. Allowances against a charge include fixed price sales and auctioning (cannot exceed 5% of total allowances)	
Hubei	Annually	Based on historical industrial emissions, freely issued by 30th June	Less than 10%. 2014: 26 Mt (8%)
Chongqing	Annually	Based on historical industrial emissions, allowance allocation for free;	Not published

Sources: SinoCarbon Innovation& Investment Co., Ltd, China carbon market report, 2014.

Grandfathering is the main methodology. Grandfathering is the most widely used approach amongst the ETS pilots, where the total amount of allocation equals to the amount of historical emissions multiplied by a reduction factor. In some of the pilots, pure grandfathering based on historical emissions is adjusted in such a way that early movers will receive recognition for their efforts by building in credits for efficient technology to the allocations. The allocation plans for Tianjin and Shanghai have clear specifications outlining how this is done. It is sometimes referred to as "adjusted grand-fathering". The disadvantage is that it always involves an element of negotiation.

Benchmarking used but to a limited extent. All pilots are trying to further reward the most efficient enterprises by applying benchmarks for selected sectors where the data allows. Despite small differences, most of the power and heat suppliers received allocations based on benchmarks of different combustion technologies and installation capacity. The benchmarking applied deviate from the approach taken in the EU ETS because for a single product (e.g. electricity), multiple benchmarks (i.e. differentiated by technology applied) are used. Apart from power and heat, benchmarks have not been deployed at a large scale except for Shenzhen. It developed benchmarks for glass (based on the tonnage of glass production) and other manufacturing industries (based on value added as activity indicator). Shanghai also used benchmarks (production based) to decide allocations to airlines and ports.

These benchmarks are developed because there is good existing reference data on energy intensity of the whole sector. When production based benchmarks can be developed, it is usually the case that the sector makes easy to distinguish homogeneous products such as electricity.

More and more pilots to experience auctioning (Table 8). Guangdong is setting an example among the pilots by deploying the use of auctioning to allocate

allowances. Guangdong requires all compliance entities to purchase at least 3% of the allowances for the period 2013-2014 at auction, starting with a reserve price of CNY 60/ton. Otherwise, entities are not eligible for receiving the rest of the allowances for free. This percentage will increase to 10% in 2015. Hubei did the first auction on 31st March 2014, and 2 $MtCO_2$ allowances were purchased at CNY20/ton.

Table 8. Auction of seven ETS pilots

Province/city	Implementation	Coming soon	Mentioned but no details	No auction
Guangdong	√			
Shanghai	√			
Tianjin			√	
Beijing		√		
Shenzhen		√		
Hubei	√			
Chongqing				√

Sources: SinoCarbon Innovation& Investment Co., Ltd, China carbon market report, 2014.

In some pilots, such as Hubei, new entities will be covered under the ETS with allowance allocations based on emissions data from the first year of operation, while other pilots such as Shenzhen and Beijing will grant new entrants allowances based on benchmarking similar to current practices in the EU-ETS. In addition to maintain the market for new entities, several pilot governments (Guangdong, Shenzhen and Hubei) will retain a small share of allowances as a reserve, that can be issued into the market if the price were to be come unexpectedly high. Guangdong has reserved 38 $MtCO_2$ allowances and published a list of 52 approved projects. These projects are either new installations or expansions of existing facilities. Shenzhen has reserved 2% for new entrants. Shanghai has set the thresholds for new projects at 2,000 tCO_2 per year, whereas other pilots keep the 20,000 tCO_2 per year. Shanghai has planned in new capacity into the allocation to manufacturing industry.

An important difference between China's pilots and other ETS is that the ETS administrators have the right to adjust allocations after the initial distribution of the allowance. Considered an enhancement by the pilots, this feature allows the ETS administrator to moderate market volatility, eliminate quotas that would otherwise contribute to steep price declines, reward enterprises that have extraordinarily low

carbon intensity operations, or protect those enterprises that provide essential public services and/or are prone to the negative effects of leakage. All seven pilots have measures that allow for the administrator to make such adjustments, but have established limits for such adjustments.

Table 9. Details in the allowance allocation of seven ETS pilots

	Guangdong	Shanghai	Tianjin	Beijing	Shenzhen	Hubei
Baseline year	2010-2012	2009-2011	2009-2012	2009-2012	2009-2011	2010-2011
Grandfathering						
sector	Power and heat cogeneration, mining, petrochemical, iron and steel	Industrial, manufacturing and public buildings	Power and heat chemical, petrochemical, oil and gas, iron and steel	Power and heat cement, chemical, other industrial and service sectors	N/A	Steel, cement, petrochemical, chemical, automobile, construction materials, fibber, paper
calculation	Historical emission* reduction factors *: multiplied	Historical emission+early action credits	Power: Historical emission per production*production Others: Historical emission*efficiency factors*reduction factors	Power: Historical emission per production*production*reduction factors Others: Historical emission*reduction factors	N/A	
Benchmarking						
sector	Power, cement, steel	Power, aviation, airports and ports	New entrants and expanded capacity	New entrants and expanded capacity	Power, water, buildings, industrial sectors	Power, steel
calculation	Benchmark*historical production*control factor	Benchmark*production	Benchmark*production	Benchmark*production	Benchmark*production	Benchmark*production
Adjust to actual production	No	Yes	Yes	Yes	Yes	Yes
Auction	3% in 2013,10% in 2015	No	No	5%	>3% from 2014	2.4%

2.4. Offset

To encourage cost-effective measures in sectors and regions not directly covered by the ETS pilots, all pilots will accept offsets generated by Chinese Certified Emissions Reductions (CCERs) projects, which are largely composed of carbon offsets from the Clean Development Mechanism that have been repurposed for use in a Chinese context. Pilots do place restrictions on the use of CCERs. The first CCER deal was initiated in Beijing on November 28, 2013, with the volume of 10,000 ton CO_2 and price of 16CNY/ton. In Guangdong, Beijing, Shanghai and Tianjin ETS pilots, the shares of offsets are 10%, 5%, 5% and 10% respectively (Table 10). In addition to helping to reduce the cost of emissions reductions in pilot regions, CCERs are also expected to support the development of capacity to set up an ETS in non-covered provinces in the future. However, there are restrictions in the pilot programs on the use of offsets that could limit supply. Hubei, for example, requires all offsets to come from local projects, while Guangdong requires 70% local offset development and Beijing requires 50% local usage. Some of the pilots also ban certain types of projects such as hydropower.

Table 10. CCER as eligible offsetting credit

Province/city	CCER (%)	Local restriction
Guangdong	10%	≥70%
Shanghai	5%	-
Tianjin	10%	-
Beijing	5%	≥50%
Shenzhen	10%	-
Hubei	10%	100%
Chongqing	8%	-

Sources: BMDRC and BMBLF, 2014; CMDRC, 2014; HPG, 2014; PGGP, 2014; SMDRC, 2013; SZMG, 2014; TMG, 2013.

2.5. MRV

The effectiveness of an ETS hinges on sound procedures for MRV. Design of MRV requirements and procedures is still in the early stages, with an electronic reporting and verification system currently under development. During the trial period, the design of procedures used by the pilots has relied on a range of sources and

international experience. In some cases, these efforts have culminated in the publication of provisional guidelines for monitoring and reporting of CO_2 emissions, which have been issued in both Shanghai and Shenzhen. In an effort to strengthen reporting cap abilities across both covered and non-covered sectors, uncovered enterprises with emissions that exceed thresholds for coverage in some pilots, e.g. Beijing, Shanghai, Guangdong and Shenzhen, are also required to report their emissions in each year

Shenzhen has promulgated the "Specification with Guidance for Monitoring and Reporting of the Organization's GHG Emissions". Beijing has promulgated the "Beijing Carbon Emissions Accounting and Reporting Guidelines (2013)", which includes the guideline for the verification and reporting of heat production and supply enterprises, thermal power enterprises, cement manufacturing enterprises, petrochemical production enterprises and five other types of industrial and service enterprises.

Table 11. MRV of Chinese ETS pilots

Province/city	Monitoring report	Emission report	Verification report
Guangdong		Mar 31	Apr 30
Shanghai	Dec 31	Mar 31	Apr 30
Tianjin	Nov 30	Apr 15	Apr 30
Beijing	-	Mar 20	Apr 5
Shenzhen	-	Mar 31	Apr 30
Hubei	-	Feb 28	Apr 30
Chongqing	-	-	-

Sources: BMDRC and BMBLF, 2014; CMDRC, 2014; HPG, 2014; PGGP, 2014; SMDRC, 2013; SZMG, 2014; TMG, 2013.

2.6. Compliance cycle

The pilot regions required complete cycle for the compliance enterprises to fulfill their obligation. Compliance enterprises must submit their allowances to the authority through greenhouse gas information management system and submit their statistic index to the Municipal Department of Statistics. Afterwards, the enterprises should submit the data verified by third party verification agencies. Competent authority will

adjust the allocated allowance based on the actual data.

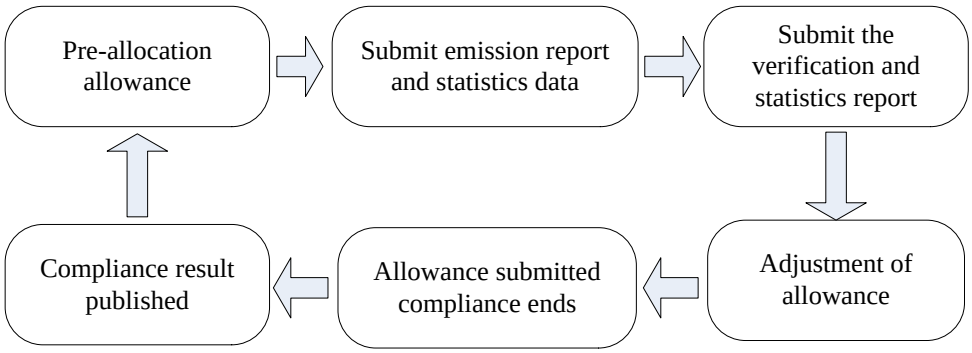


Figure 7. Compliance cycle of China ETS

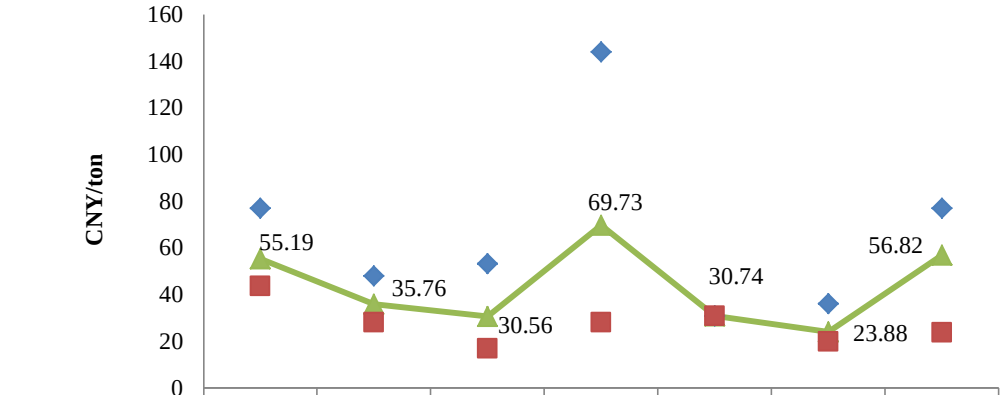
Source: tanpaifang, 2014. www.tanpaifang.com

3. Operation and Implementation of China ETS

Once the seven ETS pilots began operations, they faced challenges similar to other ETS around the world. Low carbon prices and unsatisfactory trading volumes plague the various ETS pilots. While given the different attributes of the seven pilots, some have more successful experience than others.

Launched pilots have already registered lots of carbon credit transactions. In June 2013, Shenzhen market made its first deal and its carbon price ranged between CNY28 and CNY30 per ton, where 21,000 tons of emissions permits have been traded in the spot market at the China Shenzhen Emissions Exchange. On 26 and 28 November 2013, carbon Emissions Trading Pilot Schemes were launched in Shanghai and Beijing with carbon traded at CNY27 and CNY51 per ton respectively. A survey of the carbon price of the Chinese pilots has been conducted. The carbon prices and traded volumes of the seven ETS pilots are shown in Figure 8, Figure 9 and Figure 10. The figures show that allowance prices are relatively stable. Carbon prices in the pilots to date range from approximately CNY17/tCO_2 (US$3.6) in Tianjin to CNY144/tCO_2 (US$20) in Shenzhen. In fact, Shenzhen's carbon price fluctuated dramatically, ranging from CNY28 to CNY144 from 2013 to 2014. Shenzhen allows individual investors and entities that are not covered in the ETS, such as financial institutions, to participate in trading, resulting in higher trading frequency and potentially larger price fluctuations. However, 89% of turnover fall mainly between CNY60 and CNY90, and 65% of which falls between the prices CNY70 and CNY80. The average credit price ranges from CNY23.88 in Hubei to CNY69.73 in Shenzhen. However, diverging prices may pose a challenge for the development of a national

ETS for China.



	Beijing	Shanghai	Tianjin	Shenzhen	Chongqing	Hubei	Guangdong
ceiling price	77	48	53.27	144	30.74	36	77
floor price	43.67	28	17	28	30.74	19.83	23.8
average price	55.19	35.76	30.56	69.73	30.74	23.88	56.82

Figure 8. Trading price of the pilot ETS

Source: tanpaifang, 2014. (http://k.tanjiaoyi.com/)

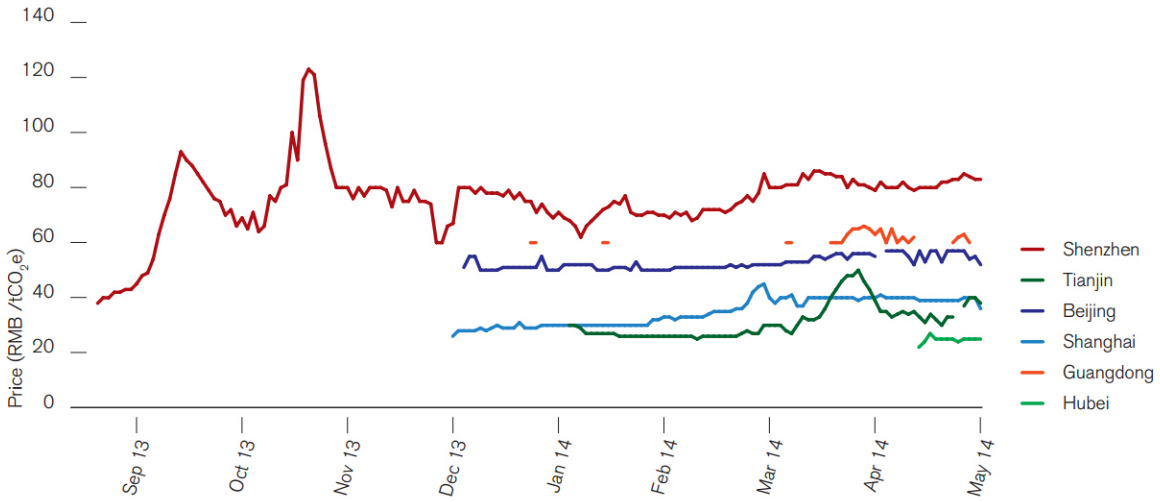


Figure 9. Price trend of the pilot ETS markets

Source: tanpaifang, 2014. (http://www.tanpaifang.com)

Figure 10(1). Price trend of Beijing ETS market

Source: China Carbon, 2014. (http://chinacarbon.net.cn/?lang=zh-hans)

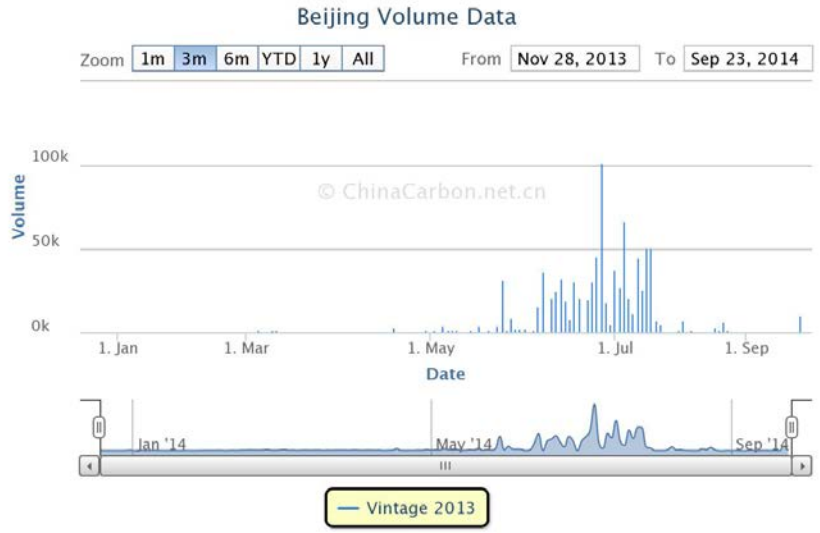


Figure 10(2). Volume data of Beijing ETS market

Source: China Carbon, 2014. (http://chinacarbon.net.cn/?lang=zh-hans)

Figure 10(3). Price trend of Shanghai ETS market

Source: China Carbon, 2014.
(http://chinacarbon.net.cn/%E4%B8%8A%E6%B5%B7/?lang=zh-hans)

Figure 10(4). Volume data of Shanghai ETS market

Source: China Carbon, 2014.
(http://chinacarbon.net.cn/%E4%B8%8A%E6%B5%B7/?lang=zh-hans)

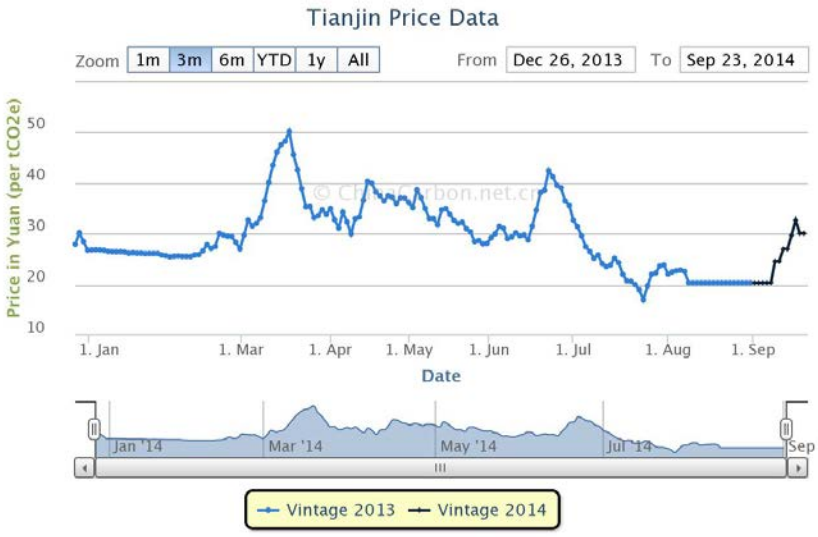


Figure 10(5). Price data of Tianjin ETS market

Source: China Carbon, 2014.
(http://chinacarbon.net.cn/%E5%A4%A9%E6%B4%A5/?lang=zh-hans)

Figure 10(6). Volume data of Tianjin ETS market

Source: China Carbon, 2014.
(http://chinacarbon.net.cn/%E5%A4%A9%E6%B4%A5/?lang=zh-hans)

Carbon price is determined by the cap of different pilots, the underlying emissions growth rate, the coverage of emissions sources by the scheme, the cost of abatement in industries covered, any provisions about price containment tools and mechanisms such as floor prices and ceiling prices, borrowing/banking of permits, linking between different pilots, use of offset credits. The lack of a unified regulatory system for China's carbon market also has led to wild variations in prices in different regions,

causing uncertainty among both buyers and project developers.

Each of the pilots manages their allowance prices differently. In Guangdong, regulators designated a price floor for auctioned allowances. Moreover, an exchange regulates allowance prices so that they cannot vary more than 10% in one day. In Shanghai, the only restriction on allowance prices is that they cannot vary more than 30% in one day.

Shenzhen ETS most thoroughly manages prices of the pilots, guarding against extreme highs or lows using a symmetric safety valve. The Shenzhen ETS introduces a market stabilization mechanism to control price fluctuation within a certain range. Two safety valves are established on the basis of a government reserve and allowance buy-back. The first safety valve is to increase market supply by selling allowances from the government reserve in the case of the price ceiling being triggered. The second safety valve is an innovative practice of the Shenzhen ETS, which increases market demand by recovering allowances from the market or reducing the carbon offset proportion in the case of the price floor being triggered. Regulators have kept an allowance reserve that equals 2% of total allocation, amounting to 2.4 million allowances for currently regulated companies, to protect against high prices. In the event that regulators determine that prices are too high, they will issue these allowances for sale at a fixed price. These allowances can be used only for compliance and cannot be traded on the market. Regulators also can buy a number of allowances back from the market if they determine prices are too low. The number of buyback allowances is limited to 10% of total allocation, or 12 million allowances for currently regulated companies. Funds for buybacks would come from auction proceeds, fines and donations.

Carbon prices in the seven Chinese pilots are low like their international comparators. Despite some pilot ETS possessing higher prices than the EU ETS, they are still not at optimum levels (World Bank 2014). This even applies to the Shenzhen ETS, which has the highest performing price out of all the pilots. According to a study published in the Journal of Biology and Engineering, the abatement cost required for the reduction of 5% of Shenzhen's total emissions is about US$20 per ton of carbon dioxide emissions (Jiao et al. 2013). Considering that the average price of carbon in Shenzhen is only a little bit over half this amount, the market environment does not seem conducive to investments by firms in reducing emissions.

Compared to the size of the markets, the volume of transactions in the operational

pilots is not large (Table 12, Figure 11). As of the end of November 2014, a total of 14.36 million allowances were traded, and the total turnover amounted to CNY500 million. The total number of traded allowance constitutes a small fraction of the total number of available allowance. For example, Shenzhen ETS pilot traded a total of 1.6 million allowances throughout its first compliance year, equal to nearly 4% of the total allowance available in the market. This indicates a very low liquidity market.

Table 12. Emissions trading volume, trading amount and average price in seven ETS pilot markets (until October 31, 2014)

Pilot	Days of trading	Initial year cap （million ton）	Trade Volume （million ton）	Trading amount (million CNY)	Average price (CNY/ton)
Guangdong	102	388	1.32	71.39	35.76
Shanghai	154	160	1.61	62.99	56.82
Tianjin	156	160	1.06	21.91	30.56
Beijing	164	50	1.01	60.23	55.19
Shenzhen	272	33	1.62	110.04	69.73
Hubei	142	324	5.90	140.57	23.88
Chongqing	134	125	0.15	4.46	30.74
Total	-	1,240	12.67	471.59	-

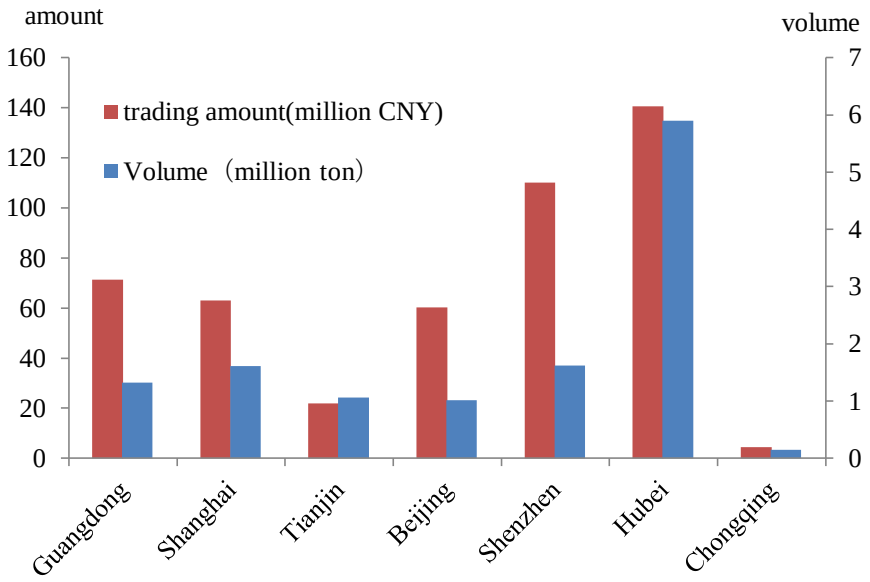


Figure 11. Comparison of trading scale in seven ETS pilot markets (Until October 31, 2014)

Source: tanpaifang, 2014. (http:// www.tanpaifang.com)

Liquidity is currently quite low in the ETS pilots, for a number of possible reasons. One explanation might be that complementary policies have negated the need for trading—having already effectively achieved the emissions reduction imposed by the pilots. Another explanation might be that the regulated enterprises face some barrier that prevents them from trading, including transaction costs that might stem from a lack of familiarity with trading. Besides, many enterprises have little experience of carbon trading.

The Beijing ETS began operations on November 28, 2013. From this period until October 31, 2014, a total of 1.01 million tons of CO_2 were traded in the Beijing ETS. Its price is still relatively high for an ETS, with an average price of CNY55.19 (US$8.7). The trading prices in Beijing are relatively stable. The Guangdong ETS began operations in December 18, 2013. In 2013, participants were required to purchase a minimum of 3% of their total allocation on auction, with a floor price of CNY60 (US$10) before the remaining 97% of allowances can be traded. The first four auctions had 10.7 million credits sold at the reserve price of CNY60. However, trading volume in the Guangdong ETS is quite low. Despite being the largest ETS in China, the Guangdong ETS only traded credits worth 1.31 million tons of CO_2 as to the end of October 31, 2014. The Shenzhen ETS was the first pilot to operate and began its trading on June 18, 2013. As to the end of October 31, 2014, the Shenzhen ETS had a total trading volume of 1.62 million tons. In 2014, Shenzhen issued credits for 33 million tons of CO_2 emissions. Along with its low trading volume, the Shenzhen ETS also has over-allocation issues. Compliance at the end of Shenzhen ETS' first compliance period was 99.4% and every firm had either surrendered the required number of credits or paid their fines. The Hubei ETS may have the lowest average price out of all the ETS pilots, with an average price of CNY23.88, but Hubei also has the least developed economy of the ETS regions and has lower costs compared to the rest of the country in general. With this in mind, the Hubei ETS seems to be one of the better performing pilots, as its carbon price is comparable to ETS of more developed regions and has the highest trading volume by far of all the pilots. The Chongqing ETS began its operations on June 19, 2014 and 16 deals were signed in the Chongqing ETS' initial launch, which totaled 145,000 credits (one credit is equivalent to one ton of CO_2) at a price of CNY30.74 (roughly US$5). To put these figures in perspective, a total of 125 million credits were issued to participating firms for them to cover their 2013 emissions. Trading volumes in Chongqing are especially

bad. While the Hubei ETS is the only Chinese pilot that trades almost every day and other ETS pilots only trade on rare occasions, Chongqing basically never has any trades in its carbon market and trading volume is the lowest out of all the ETS pilots. In its initial year, the Tianjin ETS issued credits equivalent to 160 million tons of carbon dioxide emissions. In terms of both carbon pricing and trading volumes, the Tianjin ETS has one of the lowest performances of the seven pilots. The average price of carbon in Tianjin is CNY30.56 per ton of CO_2, and 1.06 million tons of CO_2 were traded.

At present, Hubei and Chongqing have not yet received surrendered permits. Therefore, the compliance status focuses on the remaining five regions - Shanghai, Guangdong, Shenzhen, Tianjin and Beijing (Table 13).

Two of the pilots, Shanghai and Shenzhen met their compliance deadline of 30 June 2014, with Shanghai had 100% compliance rate, and in Shenzhen four industrial enterprises failed to comply by the deadline. Guangdong finished the first compliance period on 15 July 2014, after postponing the initial compliance deadline of 20 June 2014. Beijing postponed its compliance deadline from 15 to 27 June, and Tianjin pushed back its deadline twice, from 31 May to 10 July and finally to 25 July.

Up to 25 December 2014, Beijing, Shanghai, Guangdong, Shenzhen, Tianjin, had completed the compliance audit for the first time. In these five Pilot Regions, the average rate of compliance is 98.85%. Chongqing will complete its first compliance year on 20 May 2015.

To enforce the compliance of covered entities with their emissions obligations, all pilots have built a variety of public disclosure and punishment mechanisms. Some pilots include non-compliance in the credit record of non-complying enterprises and make it public. Some pilots also deprive those non-complying entities for a certain period of time from applying for public energy saving funds. Some pilots go further. For example, in the Beijing pilot, depending on the extent of noncompliance, entities are subject to fines equal to three to five times the prevailing average market prices over the past six months for each shortfall allowance. Non-complying entities in the Hubei pilot are charged at 1-3 times the yearly average market prices for each shortfall allowance, with the imposed penalty capped at CNY150,000, and two times the amount of their shortfall allowances are deducted from the amount to be allocated in the following year. The pilots have also introduced a variety of measures and policies to enhance their compliance. Several pilots have extended the compliance

deadlines. Some pilots allow the changing in status in one compliance cycle. The Shenzhen and Shanghai pilots auction additional allowances, with eligibility specified only for those enterprises of compliance gap, and the allowances received are only for compliance needs and cannot be traded on the market.

Table 13. Compliance in five ETS pilots

Pilot	Compliance period	Actual compliance	Total entities	Compliance entities	%
Shenzhen	6/2, 2014	7/3, 2014	635	631	99.4%
Shanghai	6/1-6/30, 2014	6/1, 2014	191	191	100%
Tianjin	5/31, 2014	7/1, 2014	114	110	96.5%
Beijing	6/15, 2014	6/27, 2014	415	403	97.1%
Guangdong	6/2, 2014	6/3, 2014	184	182	98.9%

Sources: collected from pilot regions, DRCs.

4. Performance of ETS in China

According to preliminary estimates, the total emissions volume of major emitting firms in Beijing fell around 4.5% in the first compliance period and the average cost of cutting emissions in Beijing has fallen by 2.5% as a result of establishing the trading platform (NDRC, 2014). In the first compliance period, the total amount of carbon emission in Shanghai decreased by 5.31 million tons, with a decrease rate of 3.5% from 2011 to 2013. While in Shenzhen, after one year implementation, the total amount of carbon emission decreased by 3.83 million tons, with a decrease rate of 11.7% from 2010 to 2013 (Figure 12).

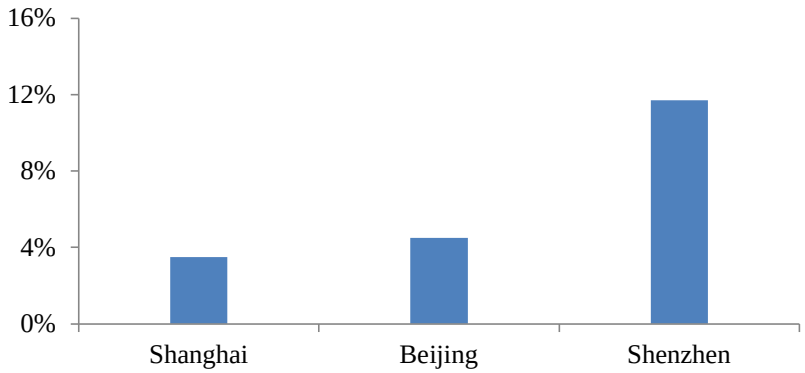


Figure 12. Emission reduction rate among the pilots
Source: China Environment News, 2014; Tanpaifang, 2014 (http://m.tanpaifang.com/article/34182.html)

4.1. Performance on Shenzhen emission abatement

4.1.1. Performance of Shenzhen ETS

Shenzhen is located on the southern coast of Guangdong province, adjacent to Hong Kong. It covers an area of 1,953 km^2 and has a population of 10.55 million, with an average income of US$19,450 per capita in 2012.

It is impractical for the government to make accurate output predictions of regulated enterprises, which is the core of government-led allocation. As a result, competitive game theory is put forward for manufacturing allocation based on the theory of bounded rationality in finite repeated games. The overall outcomes of allocation are detailed in Table 14.

In 2013, Shenzhen issued 33 million tons of pre-allocated allowance, in which energy sector accounted for 47%, and non-energy sectors accounted for the rest. In early 2014, the competent authority adjusted the amount of pre-allocated allowance according to actual output of controlled enterprises verified by the third party firm, and the actual allowance was 30 million tons.

Two compliance periods are designed in the Shenzhen pilot (2013-2014, and 2015-2016). In the first compliance period, Shenzhen ETS succeeded in achieving emission reduction target. By June 30, 2014, 631 of 635 compliance enterprises fulfilled their emission reduction obligation, with a compliance rate of 99.4%. The number of compliance enterprises that submitted allowances was largest among all pilot regions. Total amount of allowance submitted by 631 enterprises is 99.7% of total actual emission.

Table 14. Industrial sectors covered in Shenzhen ETS

Sectors	Numbers of entities	Average annual emission (10^4t)	Annual emission (10^4t)	Average annual Allocations (10^4t) (2013-2015)
Electricity	8	1,624	1,653	1,498
Oil and gas	1	9	10	9
Tap water	4	25	26	26
Electronic products	195	762	784	1,026
Metallic products, machineries and equipment	198	356	378	409

Plastic and rubber	93	127	129	130
Non-metallic minerals	24	98	114	136
Food, drink & tobacco	24	49	49	50
Others	88	107	110	119
Total	635	3,150	3,254	3,402

Source: China Emissions Exchange, 2014.

In the first compliance period, Shenzhen ETS pilot successfully catalyzed the reduction of both carbon emission and carbon intensity. The compliance results show that Shenzhen ETS pilot can help enterprises achieve emission reduction in a relative cost-effective way, that is, promote the entities to transform their production models. In the first compliance period, Shenzhen ETS made significant progress on emission reduction. After one year implementation, the total amount of carbon emission for these 635 enterprises decreased by 3.75 million tons, with a decrease rate of 11.5% from 2010 to 2013 (in 2011 the total carbon emission amount is 33.64 million tons and in 2013 this number is 29.94 million tons) and contributed substantially towards the reduction of city's carbon intensity and energy intensity. Meanwhile, these 635 enterprises have finished the mission set by "Twelve Five Year Plan" of reducing carbon intensity by 21% compared to 2010 level.

The 635 enterprises include power plants, companies in the manufacturing sector and electronic information enterprises. As Table 15 and Figure 13 shows, eight power plants alone reduced emissions equivalent to 3.06 million tons (18.2% from 2010 levels) while companies from the manufacturing sector reduced emissions by 0.08 million tones (5.2% from 2010 levels). The carbon intensity of the power generation companies declined by 4.6% while that of manufacturing enterprises fell by 33.5% compared to 2010 levels. 19 companies including Zhongxing Telecommunications Equipment (ZTE) Corporation, Huawei Technologies and Build Your Dream Company (BYD) were commended for their active role in reducing emissions and energy intensity. These 19 entities reduced their cumulative emissions by 0.31 million tons, a decrease of 6.8% compared with 2010 levels, while contributing CNY 82.3 billion in industrial added value. One of the leading companies participating in the carbon trading was Vader Industry (Shenzhen) Co. Ltd. which is reported to have purchased 0.48 million tons of emission allowances to meet its shortfall at a total cost

of 3.5 CNY million (or 7.29 CNY per ton). Companies including Foxconn and Shenzhen Skyworth-RGB Electronics Co., Ltd. reportedly made significant profits by reducing their emissions through energy and carbon-efficiency initiatives and selling surplus emission allowances. Table 16 shows the emissions reduction performance of specific manufacturing industries.

Table 15. Emission reduction performance of Shenzhen

Enterprises	Reduction emission (million tons)	Reduction rate	Carbon intensity decline	Industrial added value
Total entities（635）	3.75	11.5%	-	-
Power sector	3.06	18.2%	4.6%	-
Manufacturing industry	0.08	5.2%	33.5%	105.1 billion
Large-scale enterprises (19)	0.31	6.8%	-	82.3 billion

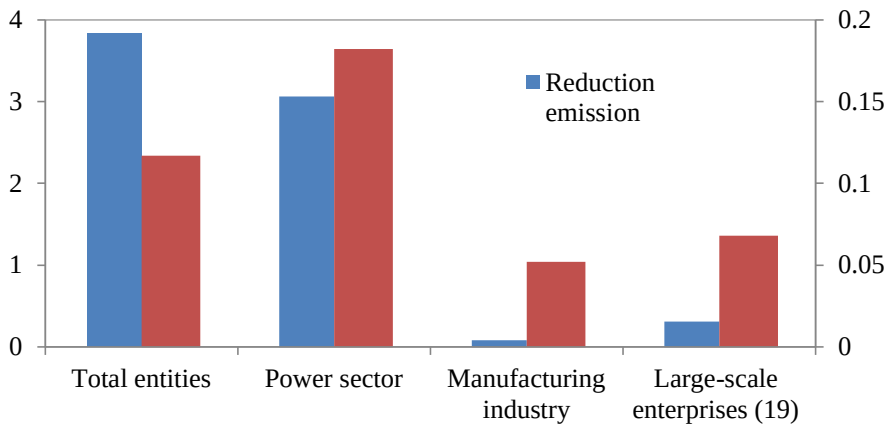


Figure 13. Emission reduction performance in Shenzhen city
Source: China Emissions Exchange, 2014

Table 16. Emission reduction performance of manufacturing industry in Shenzhen city

Industry	Emission reduction	Industrial added value	Reduction intensity
Communication Equipment, computer etc.	Decline	Increase	Declined by 39.4%
Machinery, instruments, gauges, colored metals smelting and pressing	Basically unchanged	A slight decline	-
Plastic, rubber, metal and non-metal manufacture	Increase	A slight decline	-
Paper, printing, chemical products, food and beverage	Decline	Decline	-

Source: China Emissions Exchange, 2014.

4.1.2. Case study

Case A

Company A is an active participation in the carbon market, and sells surplus allowance. Company A was founded in 2001. It was initially a “custom manufacturing with imported materials” and transformed into a foreign-owned enterprise in September 2012. Its main customers are from United States and Europe.

The company has surplus allowance and completed its compliance obligation on June 19, 2014, and it effectively fulfilling its corporate social responsibility. In 2013, the company achieved 13,129 tons of emission reduction, and its actual carbon intensity was 247.4 tons per million YUAN, a decrease of 52% to planned carbon intensity target, which was 516.5 tons per million CNY. In the first compliance period, company A achieved the emission reduction goal set by Shenzhen government. Meanwhile, the company actively participated in market transaction, and sold surplus allowances.

Company A treats emission reduction as the strategy of sustainable development of the company, and it has made reasonable and comprehensive approaches on emission reduction. Regards to energy conservation and emission reduction, the approach to achieve the goal is comprehensive and challenging. The first is to reduce carbon emission through the upgrade of industrial structure model; the second is through efficient and scientific management and develop energy-saving technology. From 2012 to 2014, the company spent CNY 6.46 million on renovation in molding machine, in paint line and in energy-saving lighting systems. The overall energy-saving rate is over 40%. The investment is mainly used for renovation in manufacturing facility, which contributes to over 70% of the total emission reduction.

Energy saving can be effective combined with competitive power promotion and operating cost reduction. The company attaches great importance to upgrade and maintain the status of the industry, thus enhancing the competitiveness through renovating equipment and technologies. The achievements of the company are mainly from the upgrade of equipment. The upgrade for 84% of its equipment has been completed. By upgrading the equipment, the company reduced electricity consumption.

Case B

Company B was founded in 1995, and it mainly produces Organic Photo

Conductor drum (OPC drum) and related peripheral products, power semiconductor related products. Each year, the company would spend a sum certain in money on energy saving. It invested CNY 8.14 million in 2012, CNY 0.9 million in 2013, and expected to invest about CNY 0.9 million in 2014. The company completed 6 and 12 energy-saving projects in 2012 and 2013 respectively, with energy saved about 364.1 and 318.7 tons of standard coal equivalents respectively. In the first compliance period, the company successfully achieved its compliance task. However, the company faced shortfall in allowance. The company used its energy management system to calculate the allowance gap, and bought some allowance via multi-band operation according to carbon price volatility.

The company has begun to devote to energy saving since 1996, thus the emission reduction space is limited after several years of development. The company belongs to hi-tech industry, and the energy consumption structure is relatively simple, with electricity as the main energy consumption type. The company plans to reduce energy consumption by 7% and carbon intensity by 25% in 5 years.

4.2. Performance on Beijing emission abatement

In 2011, the total energy consumption of Beijing reached to 69.95 million tons of standard coal equivalent (Mtce). In order to reduce energy consumption and mitigate climate change, Beijing government has set the target to cut energy consumption per unit of GDP by 17% during the period of 2011 to 2015.

In order to compare various policy design options and assumptions on economy, two policy scenarios of no emissions trading scheme among pilot jurisdictions, also called scenario business-as-usual (BAU), and emissions trading scheme containing the pilots (ETS scenario) are designed and analyzed. This study applied LEAP (Long Range Energy Alternatives Planning System) model to assess energy demand in Beijing, and then analyzed carbon emissions of energy consumption between 2013 and 2015.

The amount of a carbon emission under the BAU scenario takes the following form:

$$EB_i = \sum_{j=1}^{n} [(E_{i,j,d} + E_{i,j,t}) \times SHA_{2012,j,ETS}]$$

$$EB_{i,j,d} = EN_{i,j,x} \times EF_x$$

$$EB_{i,j,t} = EN_{i,j,e} \times EF_t$$

Where,

EB_i is the total emissions level of key emission entities in Beijing, i=2013-2015;

$E_{i,j,d}$ is the direct carbon emissions by fossil energy consumption;

$E_{i,j,t}$ is the indirect carbon emissions by electricity consumption;

$SHA_{2012,j,ETS}$ is the percentage of industry j;

$EN_{i,j,x}$ is the fossil energy consumption;

EF_x is the emission factor;

$EN_{i,j,e}$ is the total electricity;

EF_t is emission factor of external power

Table 17 and Table 18 show the emission factor for various energy and different sectors.

Table 17. CO_2 emission factor for various energy (kg CO_2/kgce)

Coal	Coke	Petroleum products	Natural gas	Power
2.64	3.15	2.07	1.63	4.82

Sources: Guidance for Beijing carbon emission verification and reporting (2014).
Carbon emission factors of Chinese regional and provincial power (2010).

Table 18. CO2 emission factor for different sectors (million tonnes CO2)

Sector	Coke	Petroleum products	Natural gas	Power	Total
Agriculture	0.88	0.29	0	0.91	2.08
Industry	9.56	13.51	2.4	16.62	42.10
Construction industry	0.22	1.49	0.14	2.1	3.94
Services	5.23	24.11	6.63	26.82	62.794.48
household consumption	4.48	9.91	2.75	11.55	28.69
Power	4.24	0.17	13.17	-	17.57
Heat supply	7.47	0.83	7.69	-	15.99
Total					173.16

Sources: China Energy Statistics Year book, 2013; Beijing Statistical Yearbook, 2013.

Table 19. Carbon Emission control coefficient of different sectors in Beijing

Method	Industry	2013	2014	2015
Historical emission	Manufactory	98.0%	96.0%	94.0%
	Service	99.0%	97.0%	96.0%
History emission intensity	Gas Infrastructure of thermal power enterprise	100.0%	100.0%	100.0%
	Coal-fired facilities of thermal power enterprise	99.9%	99.7%	99.5%
	Gas Infrastructure of heat-supply enterprise	100.0%	100.0%	100.0%
	Coal-fired facilities of heat-supply enterprise	99.8%	99.5%	99.0%

Source：Beijing carbon emissions trading approved quota method (2013).

Note: Carbon Emission control coefficient, also known as industry annual adjustment coefficient. Carbon Emission control coefficient represents the requirement of emission reduction for different industry. Allowance allocation=Historical emissions*Emission control coefficient

The amount of a carbon emission under the ETS scenario takes the following form:

$$EP_i = \sum_j T_{i,j}$$

Where,

EP_i is carbon emission in the year i, i=2013-2015;

$T_{i,j}$ is the total emission allowance of industry j

Our assessment results show that, Beijing ETS can result in a reduction of 0.41 million tons CO_2 for 2013, 1.55 million tons CO_2 for 2014, and 2.90 million tons CO_2 for 2015. These reductions make up 0.60%, 2.25%, and 4.19% of baseline scenario (BAU) CO_2 emissions for 2013, 2014, and 2015, respectively. Cumulative emissions reductions totaled 4.86 million tons (Table 20). The gradual tightening of emissions control requirements under the ETS changed the trend in total emissions. Under the ETS scenario, the 2014 emissions of key emission institutions (which are companies and organizations who are covered by Beijing ETS) already represent a drop since the previous year, reversing the increasing trend in emissions that occurs under the baseline scenario (which does not include the implemented ETS) (Figure 14). Therefore, the ETS will have an important contribution towards peaking Beijing's overall emissions.

Table 20. Beijing carbon emission and reduction 2013-2015

Year	BAU scenario(A)		ETS scenario(B)		Total Emission reduction (A-B) (million tons CO_2)
	Direct emission of fossil fuel (million tons CO_2)	Indirect emission of electricity (million tons CO_2)	Direct emission of fossil fuel (million tons CO_2)	Indirect emission of electricity (million tons CO_2)	
2013	56.15	12.53	55.99	12.28	0.41
2014	56.45	12.79	55.51	12.17	1.56
2015	56.01	13.25	54.29	12.07	2.90
Total	168.61	38.57	165.79	36.53	4.87

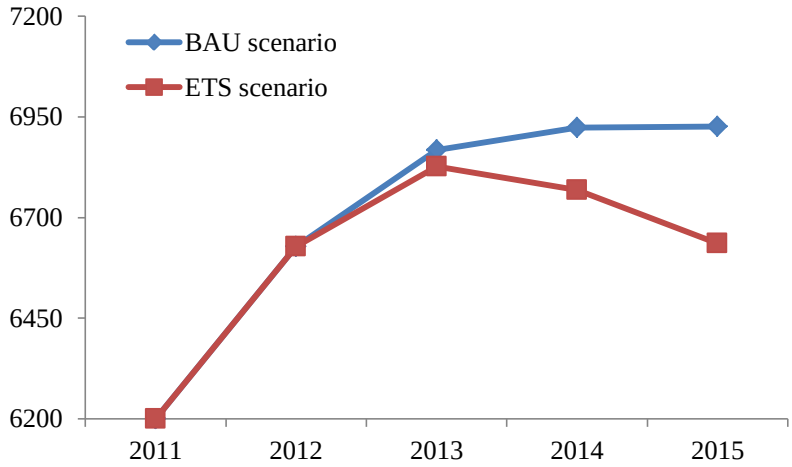


Figure 14. Beijing carbon emission 2011-2015

4.3. Performance on technology and investment

In addition to capping emissions, another key objective of ETS is to impact low-carbon technologies. Along with driving short-term switching between fuel types, by setting a price on carbon, the intention of ETS is to drive innovation in new low-carbon technologies, reduce investment in carbon-intensive products and processes, and incentivize additional investment in low carbon assets. However, the speed and scale at which carbon prices can drive this switch in technology and investment depends on the strength of the price signal created, both in terms of magnitude and long-term credibility. Much of the investment required for the switch to a low-carbon economy is on the timescale of decades; hence a long-term credible incentive is required to shift investment decisions. Assessing such impacts is

important but also challenging because ETS in China is only in its early stage of development, and public data on investment in new low-carbon plants, technologies and processes is limited and difficult to obtain. In the longer term, as more data becomes available, assessing the performance of the ETS on the scale and type of technology may become clearer.

5. Linkage of Municipal ETS

In principle, emissions trading schemes in different jurisdictions can be linked with each other, by making permits from one scheme eligible in another. This linkage of two or more emission trading systems creates a larger carbon market, which can provide the participating regions with more cost efficient options to reduce their emissions. Linking can be done either directly or indirectly and can lead to price convergence, thus offering efficiency gains. Linking offers the most potential benefit if different systems have different mitigation options and therefore different price levels. Full linkage will result in the same carbon price in all participating systems and makes the cheapest mitigation options available to all participants in the linked system. Linking would increase demand to make sure more efficient mitigation options are exploited. A larger market will also tend to be more liquid, which may increase resilience to manipulation and external shocks. There are however many barriers to linking—distributional, legal, and environmental in nature. Linking requires harmonization of rules, mutual acceptance of the scheme caps (amount of permits issued by governments) and reliable emissions accounting and enforcement in all participating jurisdictions.

In China, there were discussions in 2011 about linkage between Guangdong province and Hubei province. These discussions were intended to test the potential for linking between China's industrial powerhouses (in the Pearl River Delta and coastal regions) with the Western and Central regions, and intended to provide valuable lessons for the establishment of a national carbon trading market. The NDRC proposed that it would like to see the linkage between these two schemes, but it has not yet officially confirmed or endorsed linking.

On December 18, 2014, China's first cross-region carbon ETS was launched in Beijing. The Beijing Municipal Commission of Development and Reform (DRC), Hebei Provincial DRC and Chengde (a city in the northern Chinese province of Hebei) municipal government announced the start of the plan. The Beijing and Chengde

governments aim to "actively promote the use of market-based instruments" in handling environmental challenges across regions, according to a statement by the Beijing Development and Reform Commission. Six cement companies from Chengde will be brought into the Beijing ETS. They will have to hand over permits to the government for the first time in June 2015, the cement producers will be issued carbon permits that they can trade freely on the China Beijing Environmental Exchange, where the roughly 500 firms covered by the Beijing scheme trade their CO_2 permits. According to Beijing's carbon emissions trading rules, if a company emits more than its quota and does not purchase the right, it will be penalized three to five times more than the market price of carbon emissions. However, it remains unclear how the move will fit in with the plan to launch a national carbon market in 2017.

Before China establishes a linking scheme that incorporates emission allowances and reduction credits, key issues like the type, proportion, and source of offset, as well as a comprehensive accounting system to avoid double accounting need to be established.

6. Conclusion

The summary of the study findings is the following.

***Legal regulation*:** The seven ETS pilots generally are based on provincial and municipal administrative rules as their main legal enforcement, and complemented by some technical standards and implementation regulations. All the seven pilots have published their ETS Implementation Plans, and some pilots have released Carbon Emission Allowance Allocation Plans and ETS Pilot Management Methods.

Coverage: All seven pilot schemes cover both direct and indirect emissions (emissions from electric power generation can be considered as indirect emission). The thresholds and total number for coverage vary greatly between different pilots, with Hubei having the highest threshold of 60,000 tCO_2 per year, and Shenzhen with the lowest threshold of 5,000 tCO_2, while in EU, the threshold is 25,000 tCO_2. Enterprises representing at least 32 different sectors are included in China’s seven emission trading pilots. The seven pilots all include the following sectors: heat and electricity production, iron and steel, nonferrous metals, petrochemicals and

chemicals, paper, cement. With representatives from about 26 different sectors, Shenzhen may have the most diverse ETS. At the opposite extreme, Guangdong focuses on four sectors-cement, electricity generation, iron and steel, and petrochemicals

Cap**:** Collective CO_2 emissions in the seven pilots exceed 2.4 billion tons, and they have a cumulative cap of 1.247 billion tons including more than 2,000 enterprises. The largest is Guangdong with a first year cap of 388 million tons of CO_2 and 242 enterprises, while Shenzhen has the smallest cap with 33 million tons of CO_2. In total, about 53% of the total CO_2 emissions of these jurisdictions are included in the first year of the pilots.

Allowance**:** Allowance allocations in the seven pilot ETS are based on the local targets from the 12th FYP. While the allocation to covered enterprises is primarily based on the historical emissions data, and the allocation to new entrants is based on benchmarks or expected emissions of the planned new capacity.

Setoff**: A**ll pilots will accept offsets generated by Certified Emission Reduction projects in China. Chinese Certified Emissions Reductions (CCERs) are administered on a national basis. In Guangdong, Beijing, Shanghai and Tianjin ETS pilots, the shares of offsets are 10%, 5%, 5% and 10% respectively.

Implementation: As of the end of November 2014, a total of 14.36 million allowances were traded, and the total turnover amounted to CNY 0.5 billion. However, the total number of traded allowance constitutes a small fraction of the total number of available allowance. Up to 25 December 2014, Beijing, Shanghai, Guangdong, Shenzhen, Tianjin, Hubei had completed the compliance audit for the first time, and the average rate of compliance is 98.85%.

Performance: The total emissions volume of major emitting firms in Beijing fell around 4.5% in the first compliance period and the average cost of cutting emissions in Beijing has fallen by 2.5% as a result of establishing the trading platform. In the first compliance period, the total amount of carbon emission in Shanghai decreased by 3.83 million tons, with a decrease rate of 11.7% from 2011 to 2013. While in Shenzhen, after one year implementation, the total amount of carbon emission decreased by 3.83 million tons, with a decrease rate of 11.7% from 2010 to 2013.

Linkage: Regarding to the linkage, China's first cross-region carbon ETS was launched in Beijing. Six cement companies from Chengde (a city in the northern Chinese province of Hebei) are brought into the Beijing ETS. They have to hand over permits to the government for the first time in June 2015. However, it remains unclear how the move fits in with the plan to launch a national carbon market in 2017. However, before China establishes a linking scheme that incorporates emission allowances and reduction credits, key issues like the type, proportion, and source of offset, as well as a comprehensive accounting system to avoid double accounting need to be established.

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Appendix: Key characteristics of the Chinese ETS pilots

	Beijing	Tianjin	Shanghai	Shenzhen	Guangdong	Hubei	Chongqing
Emission Reduction Target(2010-2015)	18%	15%	19%	15%	19.5%	17%	17%
Monitored GHGs	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2
Number of covered entities	490	114	191	832(635 firms and 197 buildings)	242	138	240
Annual cap*(million tons)	78	160	160	33	388	324	130
Historical emission period	2009-2012	2009-2014	2010- 2011	2009-2011	2010-2012	2010-2011	2008-2012
Compliance Coverage	Companies emitting more than 10,000 tons of CO_2 annually, both direct and indirect (Direct emission from electricity generation and heating. Indirect emission from manufacturing and public buildings)	Carbon-intensive industries such as iron and steel, chemical, power, heating, petrochemical and exploitation and those of civil buildings, which emit more than 20,000 tons of CO_2 annually	Emission at 20,000 tons for industrial sectors(iron and steel, power, textile, rubber, materials, petrochemical, chemical, non-ferrous metals, papermaking, chemical fibber) 10,000 tons for non-industrial and service sectors (aviation, commerce, ports, airports,	Key companies emitting over 20,000 tons of standard coal. Construction, industry and service sector emitting over 5000 tons of standard coal per year, large public buildings over 20,000 square meters, office buildings for governmental agencies over 10,000 square meters	Companies emitting more than 20,000 tons of CO_2 in industries of power, cement, iron and steel, ceramic, petrochemical, textile, non-ferrous metals, plastics, and paper	Industrial companies consuming more than 60,000 tons of standard coal annually	Industries emitting over 20,000 tons of CO_2

			railway, hotels and financial institutions)				
Reporting Obligations Only	Companies consuming more than 2,000 tons of standard coal per year in the provincial area	Carbon-intensive industries such as iron and steel, chemical, power, heating, petrochemical and exploitation and those of civil buildings, which emit more than 10,000 tons of CO2annually	Other companies with CO_2 emissions more than 10,000 tons/year between 2012 and 2015	Companies emitting more than 3,000 but less than 5,000 tons of CO_2 annually, and other enterprises and buildings in specific area.	Industrial companies emitting more than 10,000 tons of CO_2	Companies consuming more than 8,000 tons of standard coal per year	N/A
Allowance Reserve and Banking	N/A	N/A	A certain amount of reserves for market interventions	Only regulated enterprises will be entitled to receive reserved allowances, which will be sold at a fixed price. Reserve 2% of the total allowances each year for new entrants.	Allowance reserve for 2013 is 38,000,000t (Reserve 9% of the total allowances each year for new entrants.)	Reserves 5% of the total provincial emissions for market interventions, another 15% for new entrants	N/A
Starting	November 2013	December 2013	November 2013	June 2013	December 2013	December 2013	June 2014
Allowance Allocation	Manufacturing, other industrial and service industries receive allowances based on historical	based on industrial emissions, mainly issued for free with partial allowance	Allocation approach based on historical emissions, allocation approach based on baselines, allocation for free or against a	Based on historical emissions per industry, allocation for free or against a charge. Free allowances cannot be lower than 90%. Charging for	Based historical emissions per industry, allowance allocation for free; 3% of the	Based on historical emissions per industry, freely issued by 30th June	Based on historical emissions

	emissions; power and electricity industries based on historical carbon intensity	allocation against a charge	charge	allowances includes mechanisms such as fixed price sales and auctioning	total allowances are for new entrants in 2013-2014; 10% of the total allowances are for new entrants in 2015		
Authorized Transaction Platform	China Beijing Environment Exchange	Tianjin Climate Exchange	Shanghai Environmental and Energy Exchange	Shenzhen Emissions Exchange	China Emissions Exchange (Guangzhou)	Hubei Carbon Emissions Exchange	Chongqing Carbon Emissions Exchange
Trading Products	Allowance, CCER	Allowance, CCER	Allowance, CCER	Allowance, CCER	Allowance, CCER	Allowance, CCER	N/A
Trading Modes	Public trading; negotiated transfers; other trading modes; OTC	Online spot; negotiated transfers and auctions	Auctions, OTC and others	Spot: electronic auctions, fixed price, block trades, and negotiated transfers	Trading modes have to be in compliance with national laws and relevant regulations	Electronic bidding; online matching	N/A
Trading Participants	Companies under the cap, reporting companies voluntarily participating, and other institutions	Companies under the cap and other institutions, enterprises, organizations, and individuals	Companies under the cap, other organizations and individuals	Companies under the cap, other organizations, individuals and investment institutions	Companies under the cap; Introducing new participants at an appropriate time	Companies under the cap, corporations or other organizations holding CC ERs	N/A
Offset Mechanisms	CCER, no more than 10% of the	CCER, no more than 10% of the	CCER, certain percentage of total	CCER, no more than 10% of the total emissions	CCER, no more than 10% of the	CCER, no more than 10% of the	CCER, no more than 8% of the

	total emissions,	total emissions	emissions		total emissions	total emissions	total emissions
Incentives and Non-compliance Fines	Fine three-five times of the market price	N/A	Fines between 10,000 and 30,000 CNY for failing to report emissions; false information or hiding important information; Fines between 30,000 and 50,000 CNY for unreasonably resisting verification; Fines between 50,000 and 100,000 CNY for failing to surrender allowances;	Fines between 10,000 and 50,000 CNY for failing to report emissions; Fines between 50,000 and 100,000 CNY for serious issues; For failing to surrender: compulsive deduction, the insufficient amount will be deducted from the following years' allowance allocation; a fine of three times the former six months' average market price will be due.	Fines three times of the average market price for non-compliance	Fines three times of the average market price	N/A
Compliance period	2013-2014	2013-2014	2013-2014	2013-2014	2013-2014	2013-2014	2013-2014

Notes: Targets of China's seven regional ETS pilots are "the reduction of CO_2 intensity." "Compliance period" is 2013-2014.