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China's Pilot Carbon Trading Schemes: Assessment and Lessons from EU

by

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Abstract

This paper assesses the seven Chinese pilot carbon schemes that will be implemented in late 2013, and relates the most critical and relevant lessons from the European Union's Emission Trading Scheme (EU ETS) to the Chinese circumstances. This paper reviews the key policy designs of the pilot schemes, and discusses the unique Chinese policies and market environment that would differentiate the Chinese schemes from the EU ETS. In terms of expected emission abatement, this paper estimates that, compared to business as usual (BAU) level, Guangdong, Hubei and Shanghai are expected to mitigate the highest amount of CO2 emissions. In terms of carbon price, this paper expects the schemes of Guangdong and Hubei to have the highest carbon price while the price in Beijing and Tianjin will be the lowest.

By reviewing EU's experience, this paper proposes recommendations on 1) avoiding allowances over-supply and windfall profits, 2) maintaining market stability, 3) bottom-level allocation, 4) use of allowance reserve and provision, and 5) sector selection and allocation. The paper finds that the unique designs of the Chinese pilot schemes indicate a lower likelihood of price crash than EU ETS. With regard to these special designs, and the size of the Chinese pilot schemes, the paper concludes that the Chinese pilot schemes have a significant global implication in terms of promoting a global-wide ETS, reforming existing ETS and setting examples for developing countries.

Preface

This thesis originates from an internship I did at Point Carbon during August and October in 2011. The internship was to conduct a research on the Chinese pilot carbon trading schemes after China officially announced to establish domestic carbon trading schemes in June in the same year. The internship was a very rich and interesting experience, from which I developed my interest into emission trading and more generally the regimes in tackling global warming. During the internship, I received tremendous help from my colleagues at Point Carbon, including Mr. Tom Erichsen, Director of Advisory, Mr. Anders Skogen, Associate Director of Advisory and Yoav Brandt, Senior Analyst. I was very enlightened from the interesting and in-depth discussion with them. The valuable guidelines and recommendations from them were critical to my analysis on this topic. I would like to use this opportunity to express my sincere gratitude to them.

I would like to express my appreciation to my supervisor Frode Skjeret for his help during the process of writing my thesis. He offered me important guidelines on how to conduct a scientific research and be focus on a specific research topic. His detailed revision on my thesis played a critical role on the progress of my thesis. Furthermore, his cutting-edged insights in emission trading were extremely helpful to improve my analysis during the phase of finalizing my thesis.

I wrote this thesis while I was working full time at Statkraft Energi AS. The whole process has been very challenging and time consuming, but I have enjoyed the whole process. The process of writing this thesis developed my knowledge and understanding towards the Chinese pilot carbon trading schemes to a new level compared to what I had during the internship. I will continue my interest in this topic and hope my thesis be useful for the readers who are also interested in how the world's largest CO2 emitter will operate its carbon trading market.

Oslo, June 15th 2013

Li Zhang

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Part 1: Background

Part 1 introduces the background of the paper. It firstly reviews the status quo of Chinese emissions and the evolution over the past decade. The key question to address is why the Chinese CO2 emissions grew at such a fast rate than anyone had anticipated. Furthermore, Part 1 reviews China's main measures to tackle the soring energy consumption and CO2 emission. The review outlines the policy framework, which includes the carbon-trading schemes. At the end of Part 1 is a brief introduction of the theory of emission trading.

1. The rapid growing Chinese CO2 emissions

The Chinese economy has been developing rapidly since 1978, at a time when China decided to open the country to the world and welcome foreign investment. Cheap labor, low-cost land, rich resources, and large amount of FDI boosted the country's manufacturing industry and China's GDP has grown to become almost 20 times bigger over the last 30 years[1]. However, rapid economic growth imposes severe environmental challenge on the country. China's economy is heavily driven by resource-intensive industries, such as steel, cement and other manufacturing sectors. Low efficiency, un-optimized production process, and under-enforced environmental regulations result in severe pollution. Chinese CO2 emissions have grown tremendously over the last decade, and this has caused a high degree of concern, both domestically and internationally. On one hand, China is one of the most vulnerable countries to global warming (National Reform and Development Committee of China, 2010). The potential consequences from global warming, such as rise of sea level, will have a catastrophic impact on the coastal regions of China, which are the major economic powerhouses in the country. On the other hand, China has faced increasing international diplomatic pressure on being required to cut CO2 emission, although it insists that developed countries should burden the prior responsibility in reducing CO2 emission.

[1] Based on 2011 data from the World Bank

Become world's biggest CO2 emitter in a short time

Just as if nobody would imagine China would become the world's second biggest economy from one the poorest countries in only three decades, no one has expected the country's CO2 emissions grow as such a fast speed. In 2000, the International Energy Agency (IEA) and Energy Information Agency (EIA) performed an emission forecast for China. However, both institutes underestimated the growth heavily. In 2000, the World Energy Outlook from IEA and International Energy Outlook from EIA predicted that China would overtake US as No.1 global energy-related CO2 emitter in around 2020. However, in reality China surpassed US in energy-related CO2 emissions in 2006(Figure 1.1). By 2009, China's share of global annual CO2 emissions had increased from 5% in 1980 to 24%, versus the share of EU as 11% and US as 17%. Chinese CO2 emissions were more than doubled by 2009 compared to 2000 level. The average annual growth rate of CO2 emissions was 9% during 2000-2009.

Mark D. Levine and Nathaniel T. Aden summarized four main reasons causing the Chinese CO2 emissions increase at a faster speed than the global energy research institutes forecast: 1) Economic reform allowing capital to flow more freely to high profit return investments which stimulated economic growth and energy demand; 2) Fast and massive expansion of urban population resulting in increased residential electricity demand and cement usage; 3) Energy mix becoming more dependent on coal; 4) Rapid growth of international trade after the entry of WTO boosting the exports of energy-intensive outputs. (Mark D. Levine, 2008)

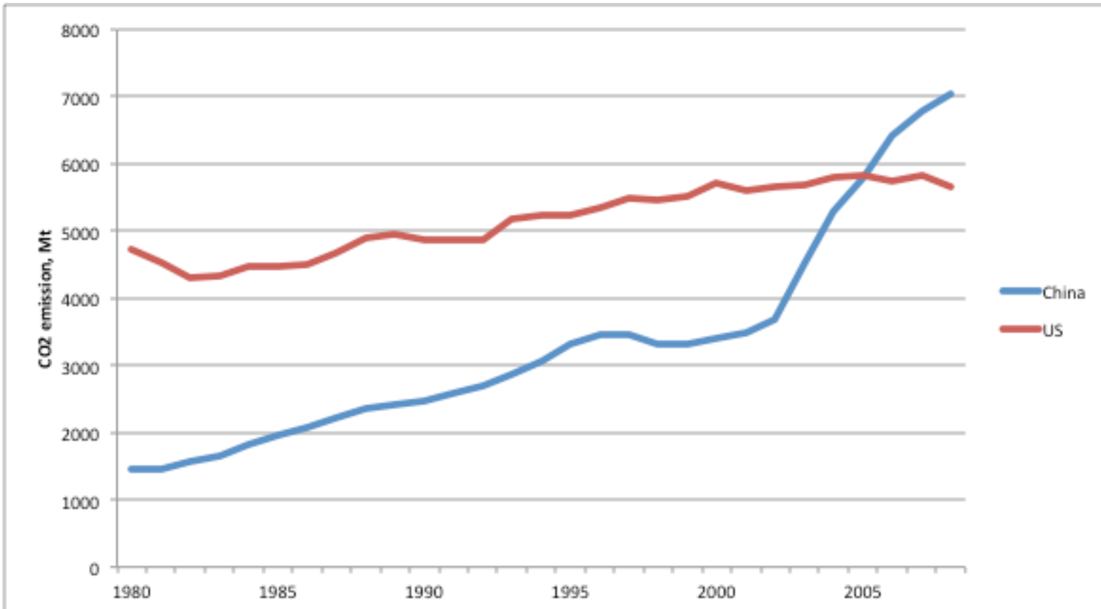

Figure 1.1 Historical CO2 emissions 1980-2009

Source: World Bank Database 2011

1.1. Carbon mitigation targets and measures

Facing the severe environmental challenges, the Chinese government has taken various policies and measures in controlling environmental problems and energy consumption. In its latest Five Year Plan (FYP), the 12th FYP, China set the target to reduce energy intensity of GDP by 16% and CO2 intensity of GDP by 17%. The targets in the 12th FYP are a continuation the previous FYP. The aspects in terms of reaching the target compromise of: 1) incorporating more clean energy source into the primary energy supply mix; 2) improving industrial energy efficiency with better designed incentives; 3) introducing market-based mechanism to optimize overcall cost of energy and emission control.

Table 1.1 Energy and Carbon Related Targets

Official Targets	11th FYP Target (2006-'10)	11th FYP Actual (2006-'10)	12th FYP (2011-'15)
Energy intensity of GDP (% of reduction)	20%	19.1%	16%
CO2 intensity of GDP (% of reduction)	No targets		17%
Share of clean energy (% of primary energy)	10%	9.8%	11.4%
GDP (annual growth rate)	7.5%	10.6%	7%

Source: (HSBC, 2011)

A brief overview of the specific measures

The content below presents an overview of China's measures for mitigation energy consumption and carbon emissions, in order for readers to understand where carbon-trading scheme is positioned in the overall policy framework, and how it is differed from other policy measures.

Improving energy efficiency

The implementation of energy intensity target is a top-down approach. The target allocated to provincial and city level is legally binding to the local governors' evaluation of performance. The potential for reducing energy intensity lies mainly in the industrial sectors, which accounts for around 70% of China's energy consumption (Daniel H. Rosen, 2007) (Figure 1.2). The giant state owned enterprises are also allocated with targets about reducing energy intensity and increasing efficiency. An example is the Top-1000 Enterprise Program during the 11th FYP. The program was aim to achieve 100 mtce[2] of energy savings from the 1000 largest enterprises in energy consumption, by referring to the fact that those top 1000 enterprises consumes 33% of national total energy consumption and 47% of national total industrial energy consumption in 2004. The

[2] Million ton coal equivalent

12th FYP explicitly mentioned energy consumption auditing and carbon emission auditing, since reliable reporting of energy consumption and CO2 emissions is the foundation in evaluating the implementation. Besides, reliable and independent audited energy consumption and CO2 emissions reports are in line with the strategic purpose of making energy consumption and CO2 emissions control more comprehensive and detailed. Compared to the 11th FYP, in the 12th FYP, the building sector is identified as a new potential area to achieve higher energy efficiency.

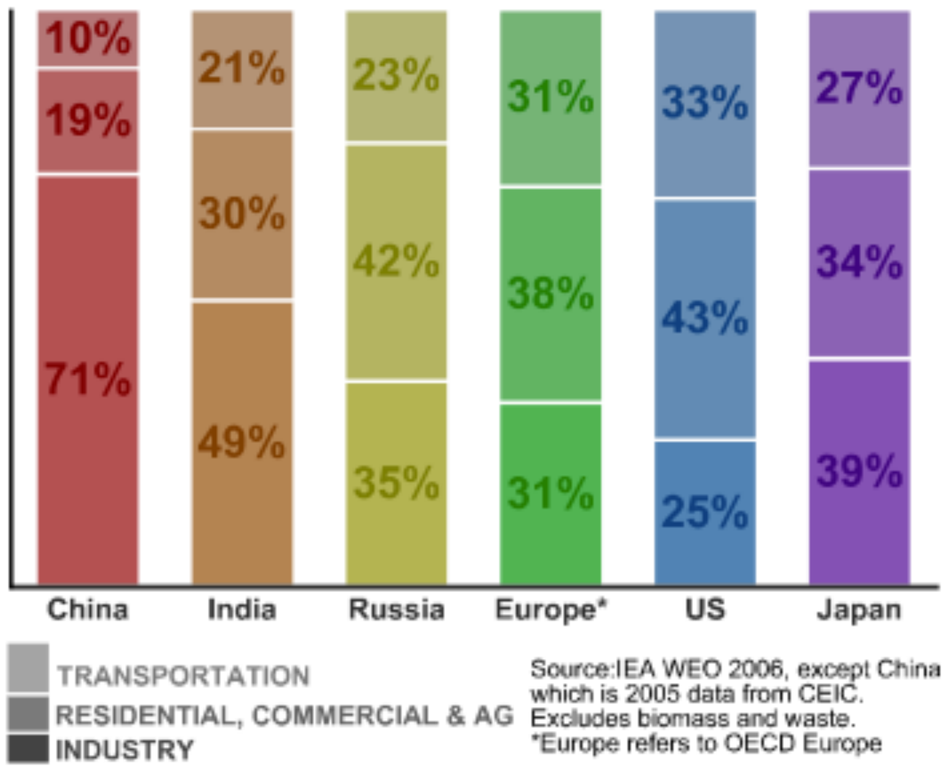

Figure 1.2 Energy Demand by Sector 2005

Source: (Daniel H. Rosen, 2007)

Cleaner energy mix

Another important aspect is to increase the share of clean energy[3], and making coal-fired power plants more efficient and cleaner. To reach the 11th FYP energy intensity reduction target, China phased out 60 GW inefficient coal-fired power capacities during 2006 and 2009. The segment of

[3] Primarily nuclear, natural gas and renewable energy

large-scale coal power plants increased significantly during these 4 years from 13% to 34%. However, the shutting down of inefficient power plants took place in the form of politically controlled approach, resulting in suboptimal cycle of power supply and demand. For instance, approaching the end of the 11^{th} FYP, local plants were forced to shut down to meet the energy intensity targets at the cost of blackout. (Tsinghua University , 2011)

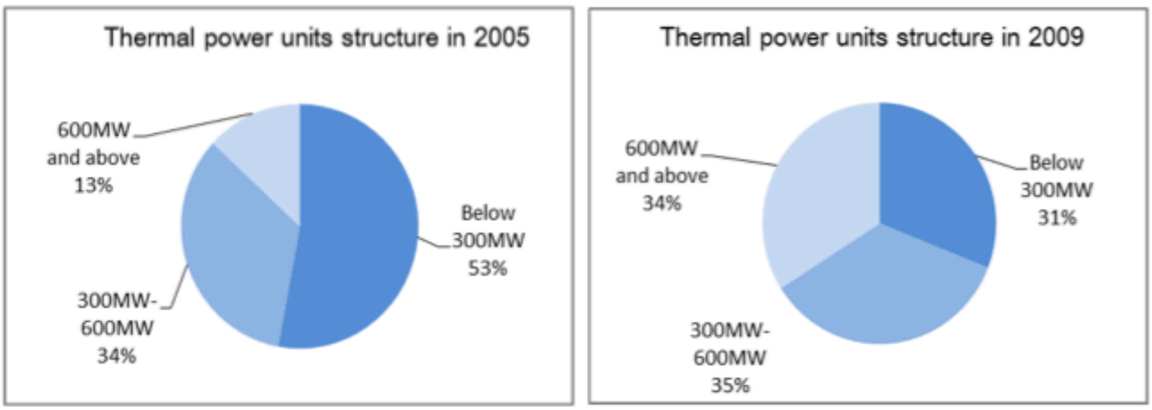

Figure 1.3 Segment of Thermal Power Units 2005 and 2009

Source: (Tsinghua University , 2011)

Market mechanism

Having seen the disadvantages of using command and control approach, the Chinese government has recognized the increasingly important role of market-oriented mechanism in mitigating energy consumption and carbon emissions. The term "market mechanism" refers to the system where, instead of politically forced actions, price plays the fundamental role in decision-marking and incentivizing. The market mechanism compromises of the reform of energy markets, carbon-trading schemes, taxations, and increasing access to financing for energy-efficiency and environmental protection related projects.

Compared to the 11th FYP, the 12th FYP emphasizes on market-based approach and bottom-up implementation flow, reflecting the recognition of the role of market by the Chinese central government. However, many challenges lie along the transitional process from central-planned to market-oriented, especially in the energy market. The deregulation took place in the 90s and yet not fundamental change has been made. Relying on the market requires the construction of infrastructure to realize the power of the market. The critical factors include market transparency, regulation to ensure fairness, sufficient number of participants to guarantee liquidity and competition. This however, might take several years to come.

1.2. Analysis on the CO2 intensity reduction target

In 2009 at the Copenhagen Climate Summit the Chinese prime minister Wen Jiabao announced China's first binding target in mitigating domestic CO2 emissions: to reduce CO2 intensity of GDP by 40-45% by 2020 below 2005 level. The fundamental difference between the Chinese target and the targets adopted by developed countries like EU or US is that the Chinese target is intensity based. Therefore, this does not indicate any reduction in absolute terms, as China insists that developed countries should primarily be responsible for absolute emission reductions.

Since the announcement of the Chinese targets, several researchers conducted research aiming to evaluate if the Chinese target indicates any additional efforts need to be taken, compared to BAU scenario. The common finding is that the Chinese intensity target requires additional efforts. David I Stern and Frank Jotzo conclude that 24% reduction in emissions intensity by 2020, not 40-45%, is reasonable business as usual scenario for China. As shown in Figure 1.4, the author forecast three scenarios of the CO2 intensity up to 2020. Scenario 1 is the author's preferred scenario as the most likely. However, in such scenario the intensity only falls by 24%. Scenario 2 and scenario 3 indicate the achievement of the targets and these two scenarios assume ambitious policies are taken to accelerate technology change and improve energy efficiency. (David I Stern, 2010)

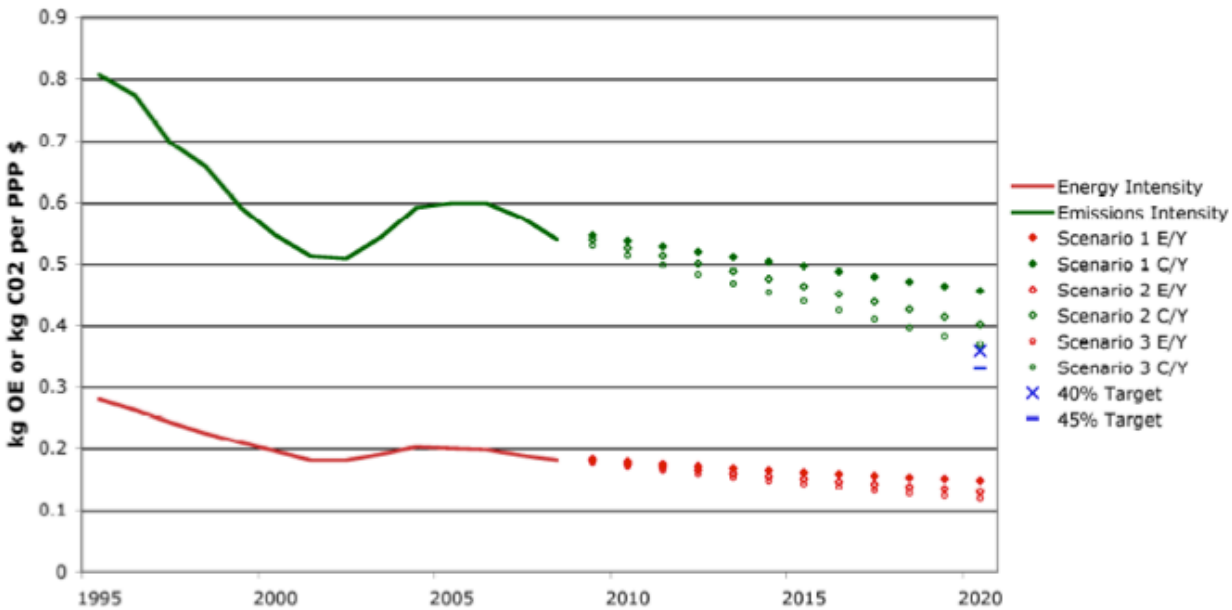

Figure 1.4 China's Energy and Emission Intensity Forecast

Source: (David I Stern, 2010)

Below I will perform another type of scenario analysis from a mathematical perspective. As explained below the change of carbon intensity is determined by the ratio of (1+annual CO2 growth rate) to (1+annual GDP growth rate). A low ratio implies CO2 emissions grows at a slower rate than GDP, and hence makes the target more possible to achieve. The interpretation of the low ratio can for instance be 1) economic structural change that make the economy more driven by low carbon sectors such as service sector, 2) improved energy efficiency that one unit of industrial output consumes less energy, 3) increased usage of clean energy such as nuclear and renewables.

$$Carbon\ Intensity_{2020} = \frac{CO2_{2005} * (1 + CO2\ growth\ rate\ p.a.over\ 2005{-}'20)^{15}}{GDP_{2005} * (1 + GDP\ growth\ rate\ p.a.over\ 2005{-}'20)^{15}}$$

$$= Carbon\ Intensity_{2005} * \frac{(1 + CO2\ growth\ rate\ p.a.over\ 2005{-}'20)^{15}}{(1 + GDP\ growth\ rate\ p.a.over\ 2005{-}'20)^{15}}$$

The result is shown in Figure 1.5: By maintaining the historical ratio of 97%[4], the CO2 intensity will only fall by 36% compared to 2005 level. If China manages to reduce the ratio to 96%, it will achieve the low-end of its intensity reduction target by 2018. Moreover, if the ratio turns out to be high, say 98%, CO2 grows relatively fast against GDP compared to historical level, China will only reduce its CO2 intensity by 26% by 2020.

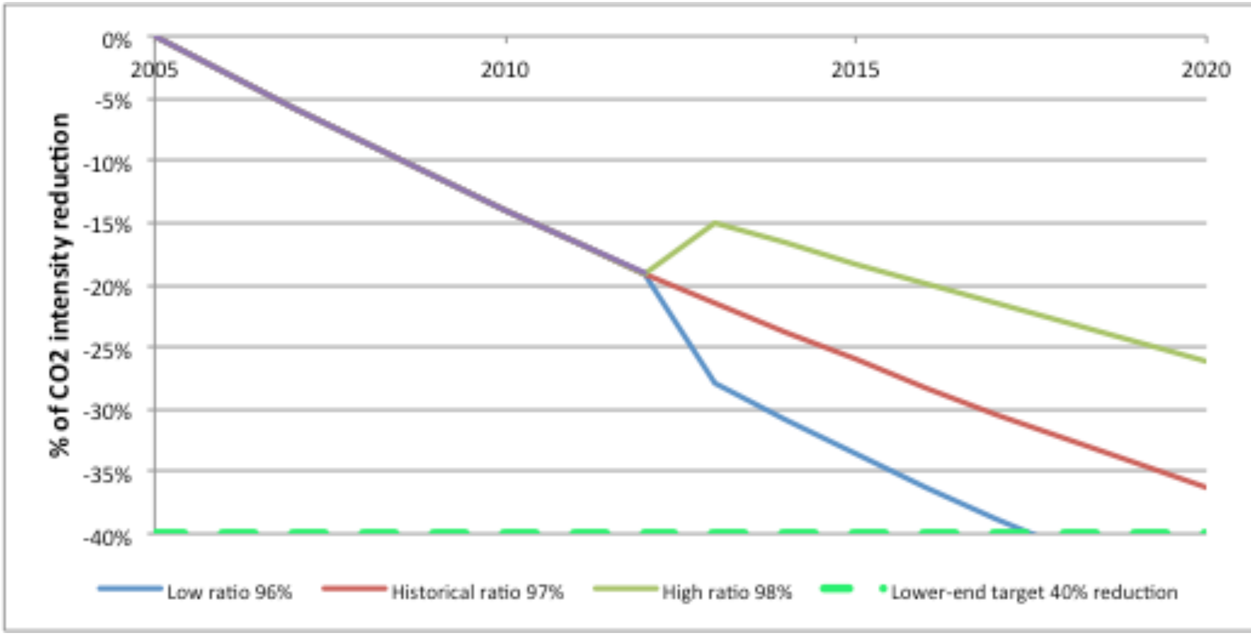

Figure 1.5 Scenario Analysis on Chinese CO2 Intensity

Source: Author's own construction

Figure 1.6 presents a more intuitive relationship between CO2 growth rate and GDP growth rate under each above-mentioned ratio. To reach the target, China must reduce the ratio from the historical level, which means to slow down the CO2 growth rate relative to GDP growth rate. On average, CO2 growth must slow down by 0.6%-1.1% relative to GDP growth compared to historical level. The Chinese government sets its annual GDP growth target as 7% over 2011-2015. Therefore, the CO2 growth rate needs to be controlled at 5.9%-6.4% over the same period.

[4] The ratio of (one plus cumulative average CO2 growth rate between 2005 and 2008 (7.9%)) to (one plus cumulative average GDP growth rate between 2005 and 2010 (11.2%))

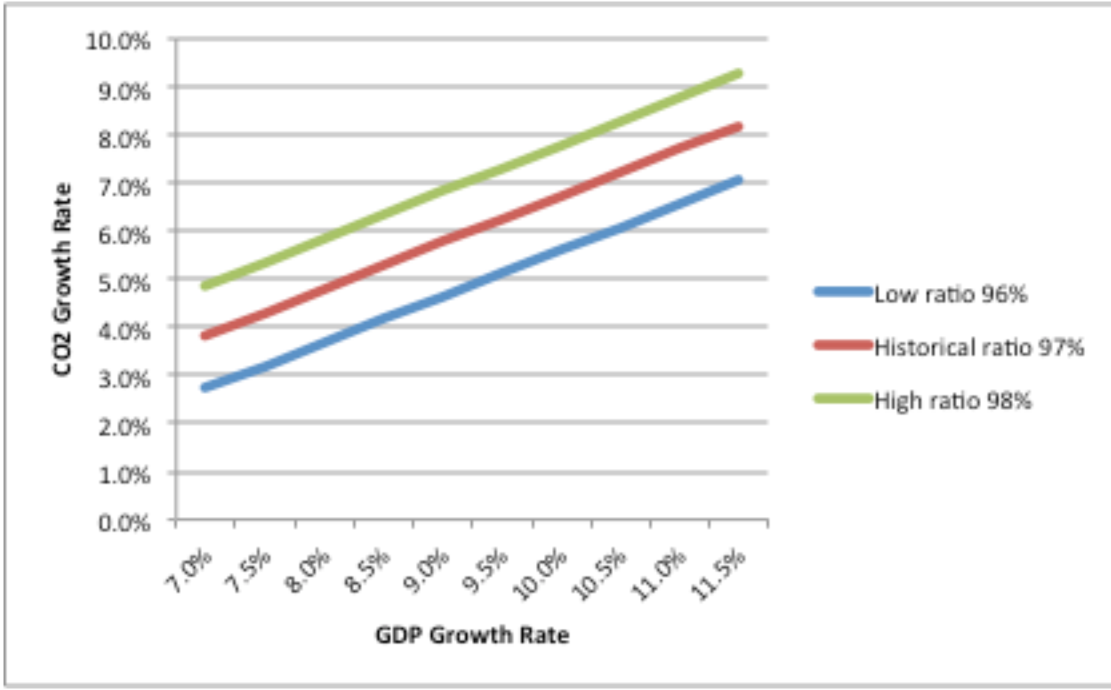

Figure 1.6 CO2 and GDP Growth Rate Under Each Ratio

Source: Author's own construction

2. Economics of emission trading

Emission trading market is an approach in environmental regulations, where economic incentives are used for reducing emissions, contrasting command and control approaches. Under command and control regulations, regulators collect information and command the polluters for specific actions to tackle environmental pollutions. The main advantage of such regulation is the simplicity in regulating a complex environmental process and therefore greater certainty in how much pollution will be controlled to emit. However, the big disadvantage is the implementation of such approach could be very costly: it requires the regulators to collect sufficient information to make the choice on behalf of the emitters in terms of pollution control. Because of this disadvantage of information collection, the possibility of information distortion is high since polluters have incentives to give false information to the regulators. (Kolstad, 2000).

In contrast to command and control, economic incentives give polluters proper incentives by rewarding pollution control. Economic incentives generally comprises of fees, marketable permits and liability. Marketable permits allow polluters to buy and sell permits for emissions. The fundamental difference compared to command and control is it provides economic rewards by allowing for trading between emitters. As a result, a price of permit is generated. The emitters hence face the economic decision: less emission means the opportunity to sell excess permits.

The graph below illustrates why marketable trading permits is more efficient than command and control approach. Firm 1 and Firm 2 emit 100 units of pollution each. Total emission is hence 200 and the regulator aims to reduce the total emission by 70. Assume under a command and control approach Firm 1 is allowed to emit 50 units and Firm 2 is allowed for 80 units. As a result, Firm 1 will need to reduce 50 units at the cost of (40*1.5+10*2=80), and Firm 2 should decrease 20 units of emission at the cost of (20*1=20). The total cost is hence 100. In contrast, under a marketable permit scheme, assume Firm 1 and Firm 2 are allocated with 50 units and 80 units, respectively. The permit market will exploit the low cost abatement potential. In this case, the total abatement of 70 unit of emission comes from 30 occurred in Firm 1 and 40 occurred in Firm 2. The permit price will eventually be set at the marginal abatement cost of the whole market. In this case is 1.5. With such a price, Firm 2 will reduce the emission by 40 and sell the extra 20 units of permits to Firm 1, and Firm 1 can hence have 70 units of permits with which the firm does not need to reduce the emission at a higher marginal cost of 2. Both firms benefit from trading the permits. Firm 2 make the profit from selling extra permits by (1.5-1)*20=10, while Firm 1 saves cost by purchasing 20 units permits as an alternative of cut its emission. The cost Firm 1 saves is (10*2+10*1.5)-(20*1.5)=5. Overall, the total abatement cost is 40*1+30*1.5=85. Compared to the total cost of 100 under command and control, marketable permits are more cost effective since the low cost abatement has been utilized in the market.

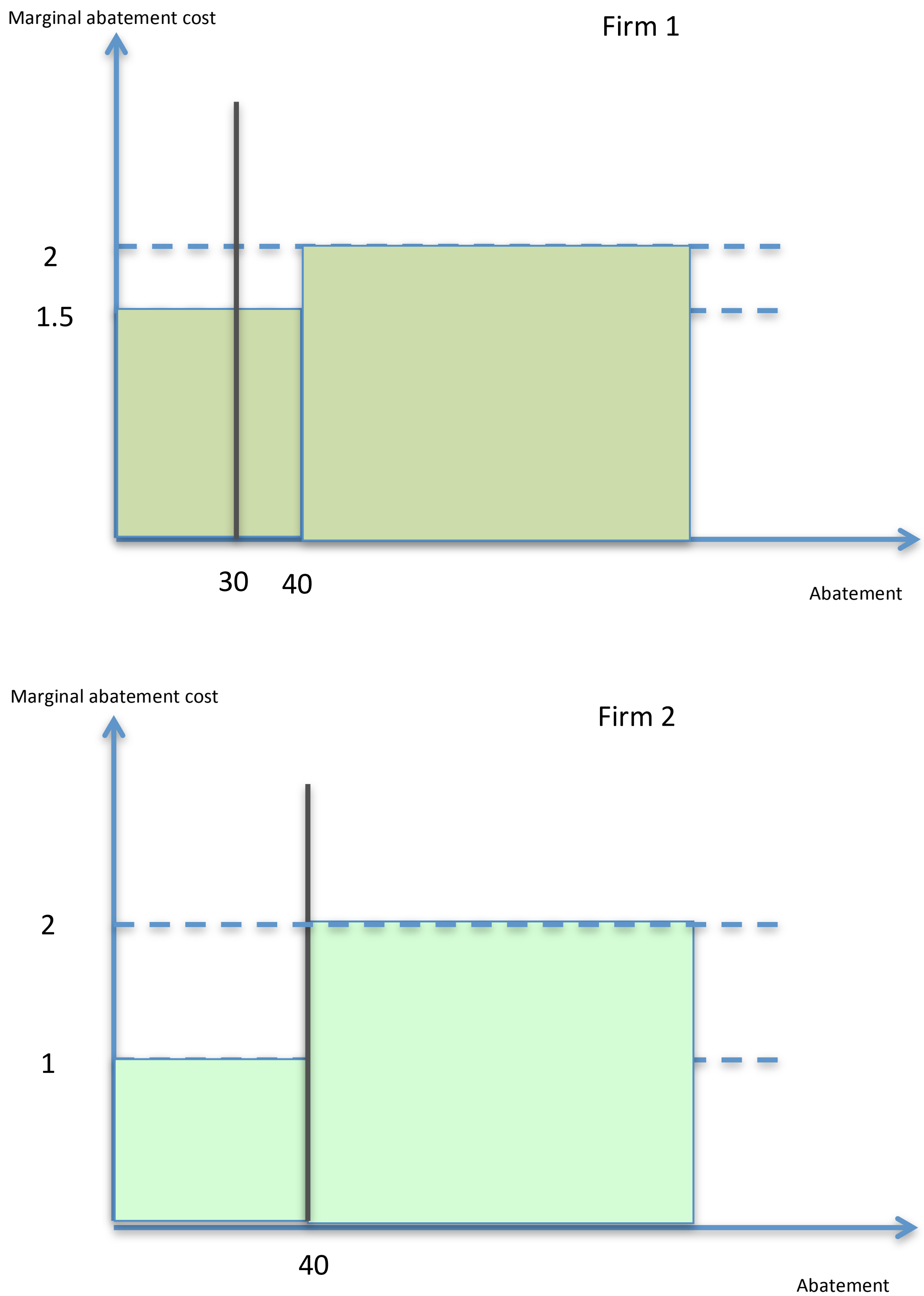

Figure 2.1 Illustration of Emission Trading

Source: Author's own construction

Nevertheless, marketable permits approach has several disadvantages as well. The first is it involves a high degree of political participation. The determination of the amount of permits, the

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distribution of the permits could be very political. If uncertainty in regulation arises, it might be necessary to induce governmental intervention (Kolstad, 2000). This, however, could be very difficult to implement, as it requires a long process before the political decision is discussed and made. Last but not least, an efficient market for trading permits requires the effective governmental administration to ensure market transparency, in order to reduce the transaction cost. The administration, again, could be very complex and challenging.

Part 2: The pilot schemes

The goal of Part 2 is to provide a thorough and in-depth assessment of the seven pilots. Part 2 includes four chapters. Part 2 first starts with Chapter 3 to introduce the basic information on the pilot areas related to economy, geographical distribution, and demographics. Chapter 3 also covers the carbon emission profile of the seven pilots. Chapter 4 reviews the policy design of the pilot schemes. Chapter 5 then devotes to compare the abatement amount required in each pilot area as well as the marginal abatement cost across the pilot areas. Chapter 6 discusses the unique Chinese energy and financial market environment that have important implication on implementing a carbon trading market.

3. The seven emission trading pilots

In April 2011 the State Council of China announced that China would implement six pilot carbon trading schemes. This decision follows the 12th FYP that China will gradually implement market-based mechanisms to mitigate energy consumption and environmental pollution. Later on, the municipal city of Shenzhen was also included to be the seventh pilot scheme. The seven pilot schemes are hence: Beijing, Shanghai, Tianjin, Hubei, Guangdong, Shenzhen, and Chongqing. (Figure 3.1)

Figure 3.1 The Map of the Seven Chinese Pilot Schemes

Source: Point Carbon

By estimate, the CO2 emissions covered under the seven pilots amounts to 800 Mt. If so the Chinese schemes will be the world's second biggest ETS in terms of covered emissions after the EU ETS.

Table 3.1 Covered Emission: Chinese and EU ETS

	Covered emissions, Mt	% of regional gross emission
EU ETS	2200	40%
China	800	8.5%

Source: Point Carbon

Point Carbon summarizes the critical ETS-related information of the pilots:

Table 3.2 The Summary of Seven Pilots

	Beijing	Tianjin	Shanghai	Guangdong	Shenzhen	Hubei	Chongqing
Estimated economy-wide emissions from energy source in 2010 (Mt CO_2e)	121	159	254	520	74	358	167
Estimated covered emissions (Mt)	60	95	110	218	40	125	67
Emissions covered by the ETS (%)	~50 %	60 %	43 %	42 %	54 %	35 %	~40 %
Number of covered companies	300	120	197	827	800	150	N/A
Coverage threshold (benchmark year)	10,000 tCO_2 (2009-2011)	20,000 tCO_2 (2009-2011)	20,000 tCO_2 for industrial and power sectors, 10,000 tCO_2 for non-industrial sectors (2010-2011)	20,000 tCO_2 or 10,000 tsce (2011-2014)	20,000 tCO_2 (N/A)	60,000 tsce (2010-2011)	N/A
Sectors covered	Power, Heating, Manufacturing, Public building	Power, Heat, Steel and Iron, Chemicals, Petrochemicals, Oil and Gas, Building	Power, Steel and Iron, Chemicals, Non-ferrous metals, Building materials, Textiles, Paper, Rubber, Chemical fiber, Airlines, Building, Harbors, etc.	Power, Steel and Iron, Cement, Ceramic, Petrochemicals, Textiles, Non-ferrous metals, Plastics, Paper	Cement, Chemicals, Rubber, Ceramic, Textile, Electronics, Oil and Gas, etc.	Power, Steel and Iron, Cement, Chemicals, Cars, Metals, Glass, Paper	Electrolytic aluminum, Ferroalloys, Calcium carbide, Cement, Caustic soda, Steel and Iron

Table 3.2 The Summary of Seven Pilots, continued

	Beijing	Tianjin	Shanghai	Guangdong	Shenzhen	Hubei	Chongqing
Offset quantitative limit	5 %	10 %	N/A	5-10 %	N/A	10 %	N/A
Offset criteria	CCERs, half in Beijing	CCERs	CCERs	CCERs, forestry	CCERs	CCERs projects within province, forestry	CCERs, forestry
Regional emission intensity reduction targets (2011-2015)	18 %	19 %	19 %	19.5 %	21 %	17 %	17 %

Source: Point Carbon

3.1. About the pilots

Geographical distribution

As illustrated in Figure 3.1, the seven pilots include 5 municipal cities (Beijing, Tianjin, Shanghai, Shenzhen and Chongqing) and 2 provinces (Hubei, Guangdong). The pilots represent the geographical coverage of China: from North (Beijing) to South (Guangdong), and from East (Shanghai) to West (Chongqing). Furthermore, the geographical distribution of the pilots represents the coverage of different stages in economic and social development. The richest parts of China lie along the eastern coast while the inland lag in economic development. The under developed inland areas are represented by Hubei and Chongqing. With such a selection, the experience from these pilots as a result will be easier to be followed by the rest of China.

In theory, a large common emission trading market is more cost-efficient since the likelihood of achieving lower-cost emission reduction increases, especially the inclusion of less developed areas with emission-intensive and less efficient industries. As shown in Figure 3.2 Beijing and Shanghai have a high share of service industry. The two most developed cities are likely to have the highest cost for emission reduction. However, if the emission trading markets of the two cities linked to the less developed areas, such as Chongqing, the marginal cost will fall to the same level as Chongqing.

The selection of the seven pilots also indicates that the ultimate goal of the Chinese government is to create a national-wide carbon trading market. While it is too early for a discussion of national-wide carbon trading market, the possibility remains.

Economy and industry

As shown in Figure 3.2, the size of Guangdong's GDP and population is the highest among the pilots: it is around three times higher than the average of the pilots. With the second largest GDP and relatively small population, Shanghai has the highest per-capita GDP among the pilot areas.

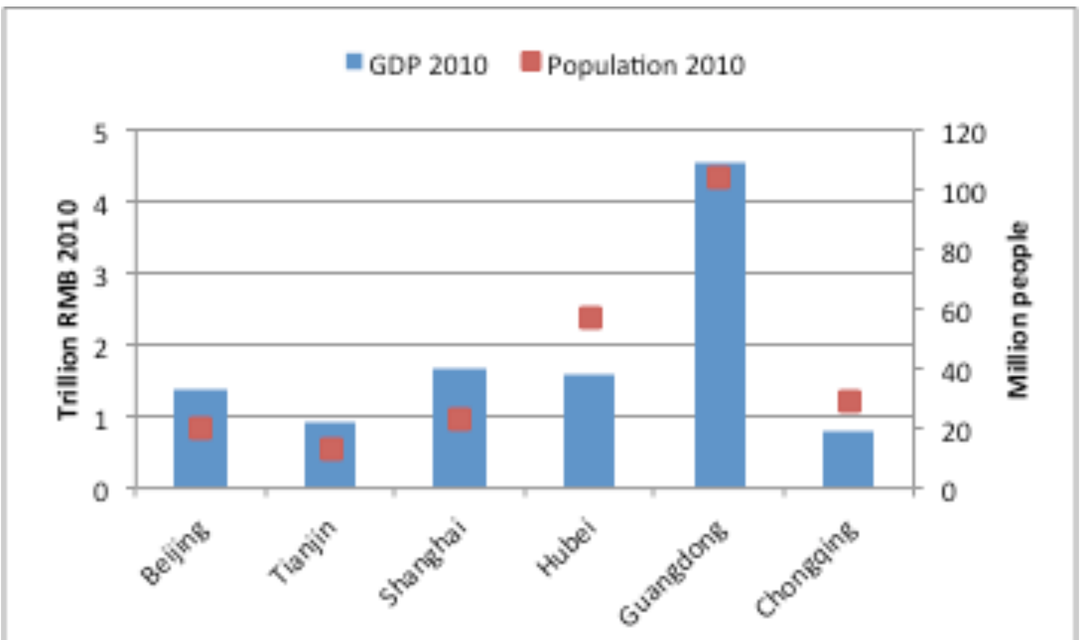

Figure 3.2 Pilot Area's GDP and Population 2010[5]

Source: China Statistical Yearbook 2011

In terms of industrial structure, the pilots have a large share of secondary industry, except for Beijing and Shanghai: on average secondary industry, which is essentially heavy industries,

[5] Due to lack of reliable data and information, Shenzhen is exempted from some of the assessment from onwards.

account for a share of 55% in total GDP. As the most developed regions, Beijing and Shanghai is shifting towards an economy that is more driven by service industry.

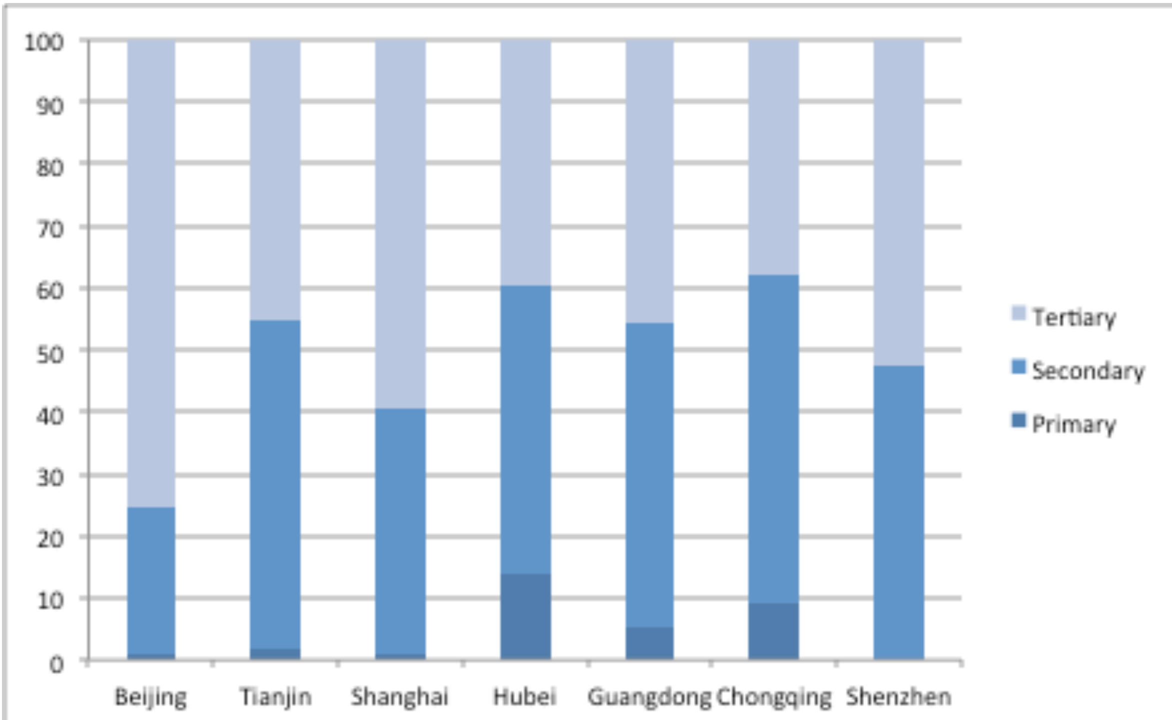

Figure 3.3 GDP Composites of the Seven Pilots 2010

Source: China Statistical Yearbook 2011

3.2. Carbon emission profile

The gross CO2 emissions from the seven pilots amount to around 1.6 Gt, the gross emission covered by ETS in total is some 800 Mt.

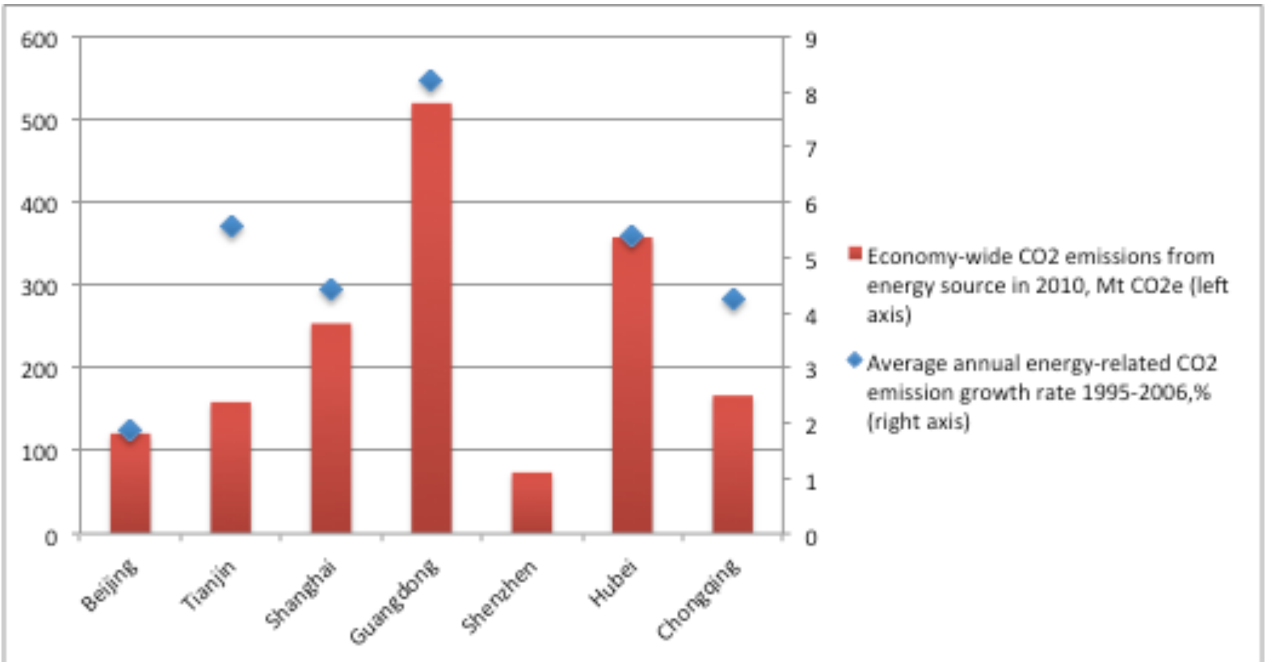

Figure 3.4 Pilot Areas' CO2 emissions and Growth Rate

Source: Point Carbon, (Wang Zheng, 2008)

In terms of carbon intensity, Hubei and Chongqing have the highest carbon intensity of above 200 ton CO2 per thousand Ren Min Bi (RMB) of GDP. The high intensity is primarily due to the high share of heavy industry in these two pilots. Following Hubei and Chongqing is Tianjin, which has a carbon intensity as 175 ton CO2 per thousand RMB of GDP, as Tianjin has a large production of steel.

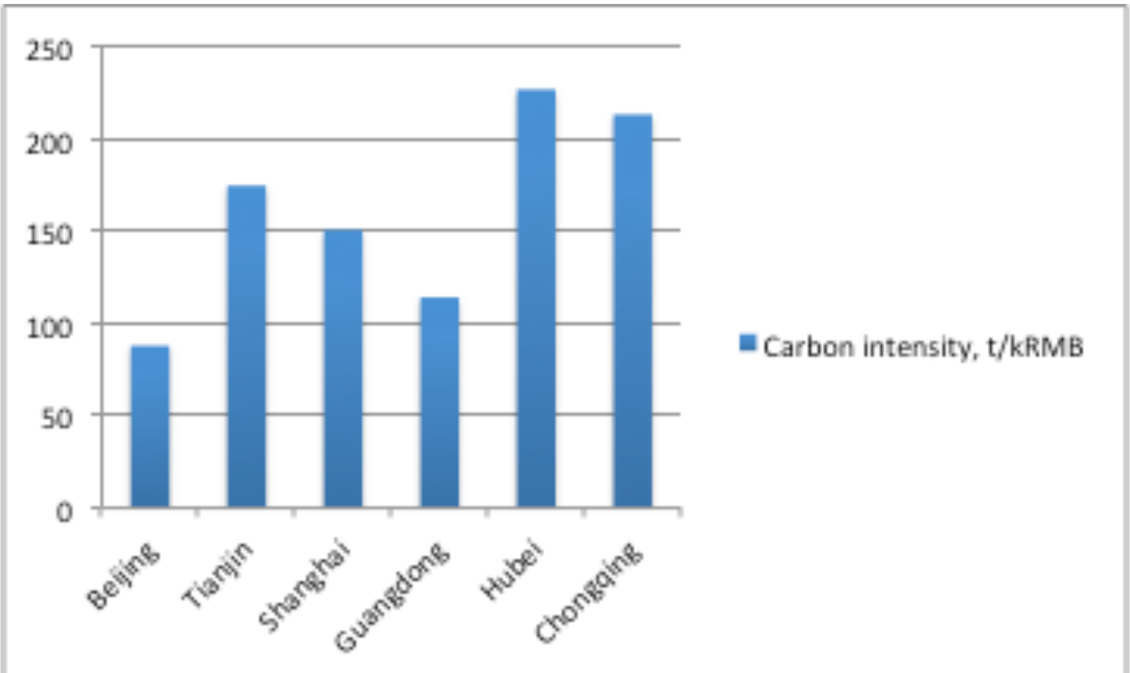

Figure 3.5 Carbon Intensity by Pilot Area 2010

Source: Point Carbon, China Statistical Yearbook 2011

4. The design of the schemes

4.1. Review of key policy design

So far, there have been any published official documents concerning the specific regulations and policy of the schemes. However, officials have released key information and indication on the policy design of the scheme. This session will review and summarize the key information.

Allocation and trading at company-level: News indicates that the majority of the entities covered under the schemes are companies, compared to installation in the EU ETS[6]. The advantages is that company can use various measures to reduce emission, from upgrading production technologies, improving energy efficiency of the office building, to replace old cars with the new ones that are more fuel-efficient. Various measures are applicable for the company

[6] 21st Century Net Mar 2013, "Seven pilot schemes might start trading this June" http://epaper.21cbh.com/html/2013-03/26/content_62503.htm (in Chinese)

as long as they are acknowledged by the scheme. The disadvantage, however, is the complexity in monitoring the emission reduction from various measures taken by the company. Carbon leakage is another risk. In general, there are three channels of leakage: 1) from included sectors to non-included sectors within one scheme, 2) from the schemes to regions outside the schemes within China, and 3) from schemes in China to abroad. The first and third channels are less likely. For the first channel, the wide sectoral coverage of the Chinese schemes eliminates such form of leakage to a large extent. For the third channel, moving production abroad means the companies lose the access to low manufacturing cost in China. This seems unlikely from a cost-benefit perspective. However, the second channel of leakage, where companies move out production to regions outside the schemes within China, are very possible to occur once the carbon cost increase to a level at which it is more profitable for the companies to relocate production to save carbon cost.

CO2 is the only greenhouse gas covered: In the pilot period China only cover CO2. The EU also chooses CO2 as the main GHG gas to cover under the scheme. Feasibility is the main reason for only covering CO2, as CO2 is relatively easier to monitor and verify. A close approximation of CO2 emissions can be derived by multiplying energy consumption with the emission factor corresponding to the specific technology.

Spot trading only: China is still in a very early stage in developing a sophisticated and well-functioning financial forward markets, especially for commodities. An introduction of commodity forward products requires lengthy assessment by policy makers, of which the China Securities and Regulatory Commission (CSRC) is the key decision maker. China's main concern is speculation activities might negatively affect the economy. SCRC indicated that China should start a carbon market with spot trading only, while at the same time developing the infrastructure of forward trading. The implementation of forward carbon trading, however, could be a long process. The planned launch of crude oil futures has been slow although this product is fully supported by CSRC[7].

Annually-set cap: Unlike EU, where cap for a period of years is pre-determined, some Chinese schemes indicate a different frequency in setting the cap. Hubei for instance, will set the cap each year based on previous year's emission. On the other hand, this also indicates China might not use an absolute cap that diminishes over the year.

Offset is allowed: Hubei for instance allows companies to use offset credits[8] for compliance of up to 10% of the allocation.

Banking and borrowing permits not allowed: Hubei, as an example, regulates that in the first three years all companies need to sell surplus permits at the end of each compliance year. In other words, permits allocated for a year is not valid for compliance in the following year. So far, the indication is that the regulators would be the primary buyer of surplus permits at the end of each trading year. However, the fact that companies can sell permits they were awarded for free, might affect public budgets in an adverse manner.

Set-aside reserve permits: Indications suggests that the pilot schemes will reserve a certain amount of permits not only to supply the demand from new entrants, but also to prevent the price from being too high by dumping reserved credits to balance the supply and demand.

Exchange involved in designing the scheme: Local exchanges are heavily involved in supporting the regulatory bodies in establishing the scheme. Most of the exchange are by majority owned by state-owned entities, or backed by local governmental bodies related to state-owned asset management. In Shanghai, the exchange is even the main designer of the scheme.

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[7] Point Carbon Mar 2013, "CORRECTION: Will 2013 mark the dawn of China ETS?", http://www.pointcarbon.com/research/marketsoverview/analysis/aus/1.2218885?date=20130313&sdtc=1

[8] More detailed explanation and discussion on offset credits is in Chapter 9.

4.2. Covered companies and sectors

Covered companies and sectors

Table 4.1 compares the number of companies and sectors that are expected to be covered under each pilot scheme.

Table 4.1 Coverage of the pilot schemes

	Beijing	Tianjin	Shanghai	Guangdong	Shenzhen	Hubei	Chongqing
Number of covered companies	300	120	197	827	800	150	N/A
Coverage threshold (benchmark year)	10,000 tCO2 (2009-2011)	20,000 tCO2 (2009-2011)	20,000 tCO2 for industrial and power sectors, 10,000 tCO2 for non-industrial sectors (2010-2011)	20,000 tCO2 or 10,000 tsce (2011-2014)	20,000 tCO2 (N/A)	60,000 tsce (2010-2011)	N/A
Sectors covered	Power, Heating, Manufacturing, Public building	Power, Heat, Steel and Iron, Chemicals, Petrochemicals, Oil and Gas, Building	Power, Steel and Iron, Chemicals, Non-ferrous metals, Building materials, Textiles, Paper, Rubber, Chemical fiber, Airlines, Building, Harbors, etc.	Power, Steel and Iron, Cement, Ceramic, Petrochemicals, Textiles, Non-ferrous metals, Plastics, Paper	Cement, Chemicals, Rubber, Ceramic, Textile, Electronics, Oil and Gas, etc.	Power, Steel and Iron, Cement, Chemicals, Cars, Metals, Glass, Paper	Electrolytic aluminum, Ferroalloys, Calcium carbide, Cement, Caustic soda, Steel and Iron

Source: Point Carbon

Commonly most of the pilots cover the sectors that traditionally have been the major emitter, such as power and heating, steel and iron, cement and chemicals. What appears interesting is that the building sector, not covered by EU ETS, will be covered in Beijing, Tianjin and Shanghai. Shenzhen as a single city includes a large number of companies under the scheme. By including buildings as emitters, the Chinese pilot schemes indirectly covers sectors not regarded as heavy emitters, such as the financial sectors, commercial properties, which in the Chinese schemes must comply the emissions from their buildings.

Guangdong, as the biggest economy among the seven pilots, includes a large number of industrial companies, with a large number of cement companies. Guangdong will include some 120 cement producers in the scheme.

China allows freedom and flexibility for the pilots to choose the sectors and size of companies to be included. Table 4.1 also shows that emission-threshold for companies differ between pilots. In Beijing and Shanghai, the threshold level of emissions is 10 000 ton per year, only half of the threshold in Guangdong. Hubei, in contrast, chooses energy-use as threshold benchmark to filter the companies to be covered. The firms are chosen based on a threshold level of for example emissions. There is however no source explaining how the threshold is determined. In principle, the historical emission and energy consumption data used to determine the threshold should be verified, since firms have the incentives to report low historical emission levels.

5. Abatement cost and carbon price

Before the implementation of a national-wide emission trading scheme, carbon prices will differ between pilots because of the strictness of the pilot's emission mitigation targets, historical emissions as well as its marginal abatement cost curve. This session compares the pilots' carbon price by estimating the abatement cost. However, lack of research on estimating the carbon abatement cost on the level of Chinese provinces, as well as the lack of sufficient and reliable data related to historical emissions makes this a challenging task. Estimation of sectoral emissions and so on must therefore rely on simplified assumptions and inputs with limited quality[9].

There are several important reasons to estimate and compare the possible carbon prices between the pilots. Firstly, the carbon price indicates the market value of the scheme. A high carbon price incentivizes more attention on the market. Companies short in carbon must consider how to hedge their carbon exposure and minimize compliance cost; while companies that are long in carbon must optimize their strategies for selling their permits. Low carbon price, due to either low mitigation costs or over-supplied permits, indicates that the carbon cost is a minor issue for decision-making. As a result, the market would not be active. Secondly, the carbon price is the fundamental signal for making investment decisions. Pilots with relatively high carbon prices are more likely to attract investments of carbon mitigation technologies. However, a high price also implies a larger degree of uncertainties in terms of the impact on emitters. High carbon cost would mean a large reduction in revenues in the companies with high emissions. This impact, from a broader perspective, will influence local economic development and employment.

The first estimate is the expected mitigation of each pilot, which is the gap between business as usual (BAU) emissions and targeted emissions. The targeted emissions is based on the assumption that: the pilot's GDP grow at historical rate[10] over 2011 to 2015, how much would the annual emission be to meet the pilot's emission reduction target in the 12th FYP.

Figure 5.1 and Figure 5.2 show the result[11]. In Figure 5.1 one can see that most pilots expect steady emission growth over 2011 to 2015 except Guangdong and Hubei. Guangdong and Hubei have relatively high annual emission growth compared to the rest of pilots. Guangdong experienced an average growth of 11% during 2005 and 2007, while Hubei's emissions grew at

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[9] For the details of the assumptions and inputs for the following assessment, please go to Appendix I.
[10] Average annual emission growth rate during 2005 and 2007
[11] Due to lack of data, Chongqing and Shenzhen are not assessed.

10.4% over the same period. The primary driver for the emission growth was rapid growth in heavy industrial sectors.

Figure 5.2 presents the expected mitigation amount if the pilots meet the emission intensity reduction target while keeping GDP growth at historical levels[12]. Guangdong, the largest and fastest growing emitter among the pilots, is required to reduce the emission by 281 Mt compared to BAU level. Shanghai and Hubei need to reduce emission by 40-50 Mt. The high mitigation amount for Shanghai is due to the historical GDP growth and emission growth were quite close to each other; therefore, to achieve lower emission intensity of GDP Shanghai needs to maintain a low emission growth.

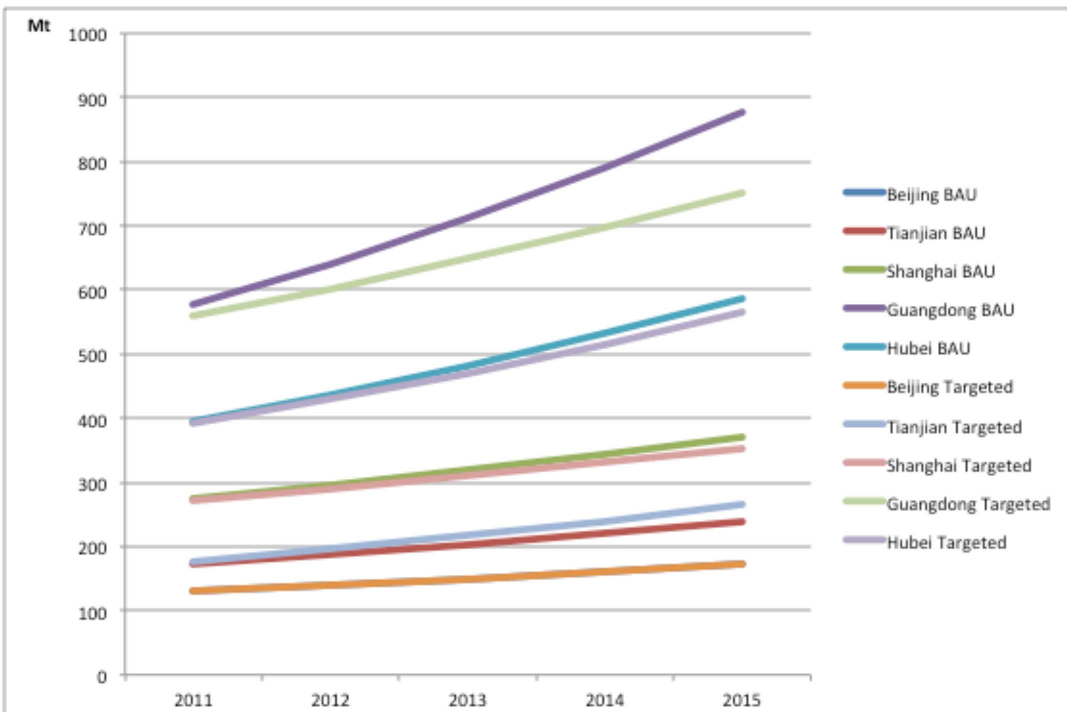

Figure 5.1 Pilots' BAU and Targeted Emission 2011-2015

Source: Author's own construction

[12] Average annual GDP growth rate during 2006 and 2010.

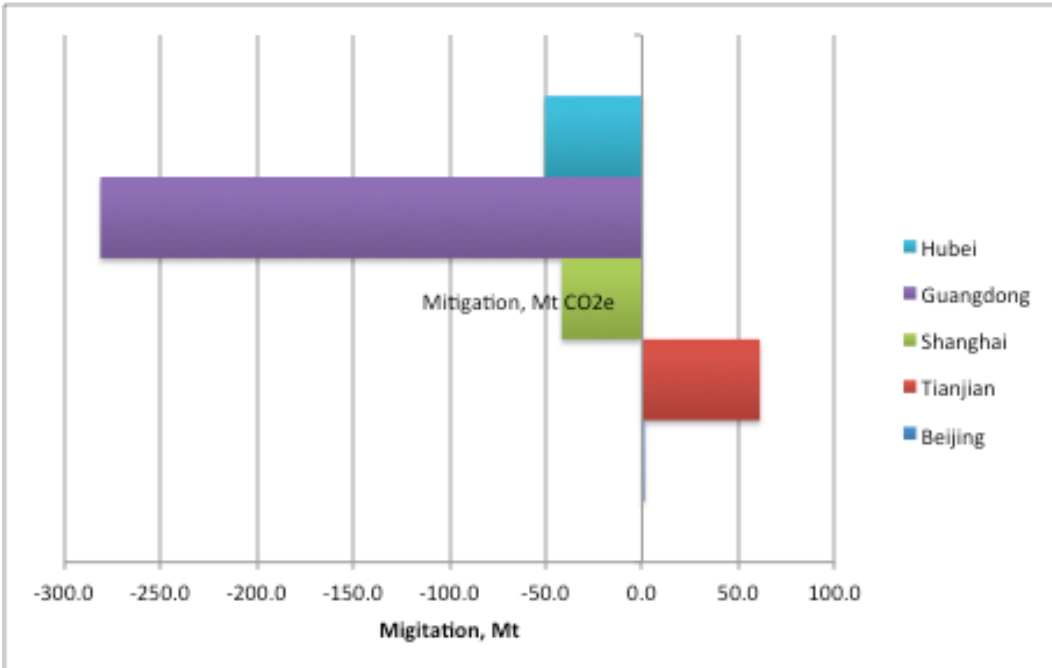

Figure 5.2 Mitigation amount by pilot

Source: Author's own construction

One interesting observation is that Beijing and Tianjin can emit more than their target. Especially for Tianjin: the municipal city can emit more than 60 Mt compared to BAU emissions, because over the past years the city has managed to reach an extremely high GDP growth rate of 16% while emission only growth at 7.9% annually. Therefore, if Tianjin manages to keep the GDP and CO2 emissions growth rate at historical level, it would reach the intensity target naturally. The challenge though, is that the assumption of keeping such a high GDP growth rate versus a low emission growth rate is rather unrealistic.

The estimated mitigation levels lay the foundation for estimating the abatement costs. The abatement cost is estimated in the following manner: constructing the abatement cost curve with regards to levels of abatement, and the cost is hence the abatement cost at which the abatement will be achieved. As demonstrated in Figure 5.3.

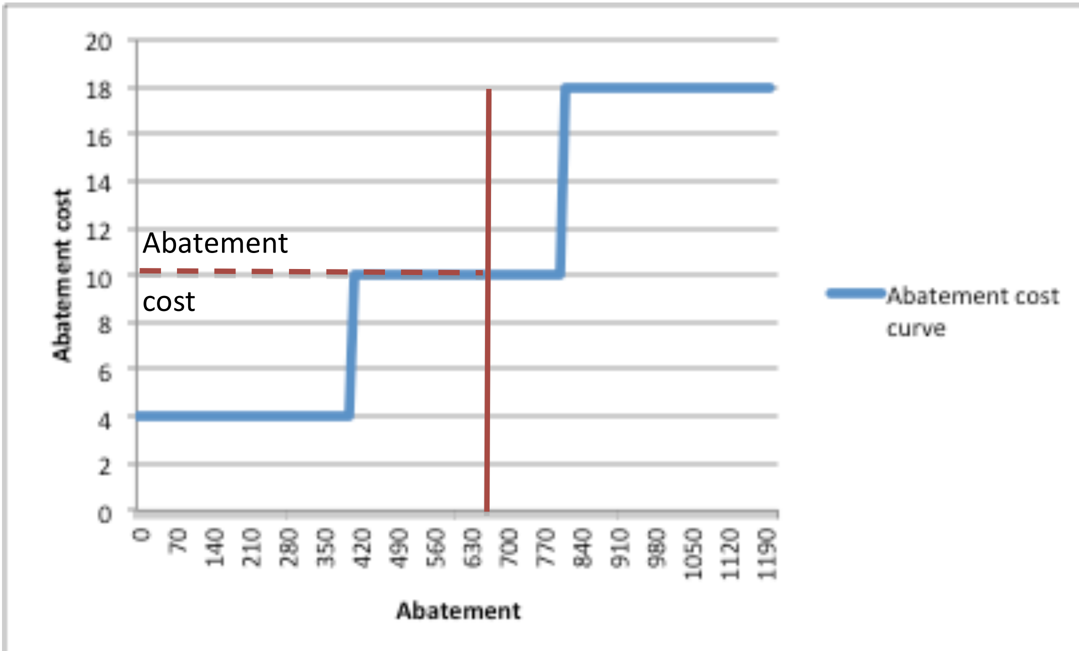

Figure 5.3 Abatement Cost Demonstration

Source: Author's own construction

The inputs of abatement cost curve relies on a research on marginal abatement cost in China from (Ellerman A.D, 1998), (J, 2000), (Tulpule V, 1998) and summarized by (Gao Pengfei, 2004).

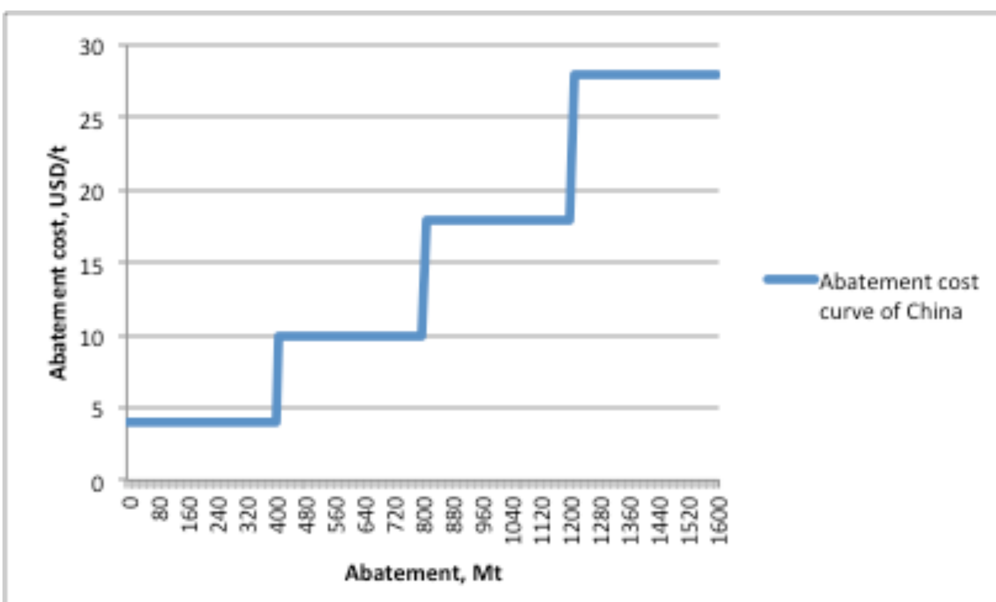

Figure 5.4 Marginal Abatement Cost Curve of China

Source: (Gao Pengfei, 2004), Author's own construction

By assuming the same curve shape of the pilot as China, and the abatement is a portion of China at the ratio of the pilot's gross emission to China, the marginal abatement cost of the pilots is estimated as:

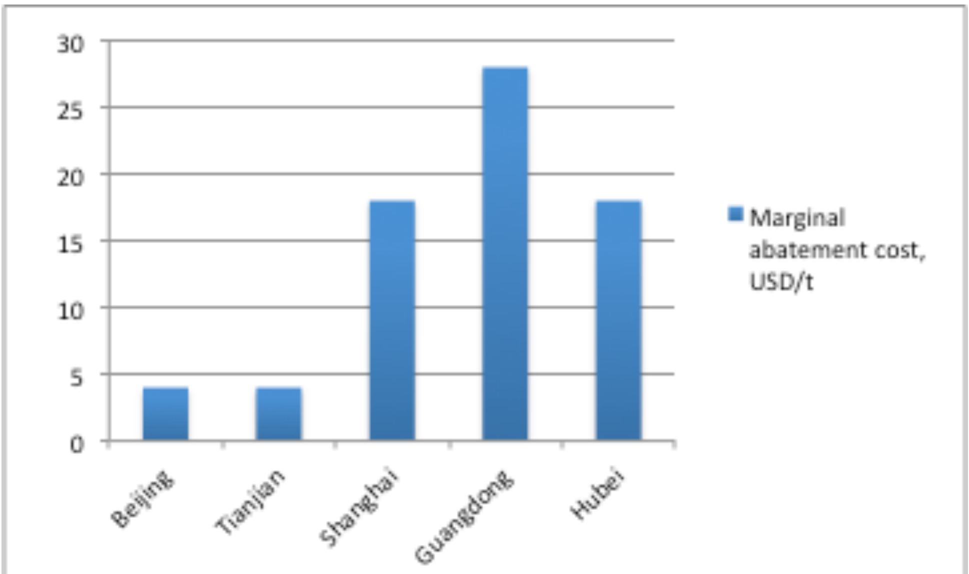

Figure 5.5 Marginal Abatement Cost by Pilots

Source: (Gao Pengfei, 2004)*, Author's own construction*

The challenges for the model are the lack of sufficient and good-quality data, and lack of sufficient research on modeling the Chinese emission abatement. As such, the absolute number of the cost might be biased since they are heavily relied on simplified assumptions. The estimation brings indicative results that Guangdong, Hubei and Shanghai are more likely to have the highest carbon price. The primary reason is the large amount of expected abatement in these three pilots.

As a consequence, the companies in Guangdong are likely to surrender under high carbon cost compared to the rest of the pilots. Given that the covered emission in Guangdong is much larger than the other pilots, the value of carbon market will be significantly larger with the high price. In the early phase, Guangdong is likely to be most interesting destination for market participants in carbon investment.

6. Carbon trading in the Chinese context

6.1. Highly regulated power market

The power sector is the sector with the largest potential to achieve emission mitigation, especially the Chinese power sector, which is the world's biggest emitter in term of sector (Green Peace, 2008). When considering emission trading in the power sector, it is important to notice that the European power sector is the most liberalized power market in the world. The deregulation of power markets has been through a long process in Europe. Regions in Europe such as the Nordic countries and Germany, have successfully implemented efficient power trading platform, promoting competition in power wholesale market. This is represented by large amount transaction volumes, large number of market participants including power producers, retailers and traders, and the transparency in pricing and disclosing market information. Successful power trading platforms are represented by power exchanges such as Nordpool and EEX. With an effective market, the cost for power generation would be priced and reflected by the prices.

The Chinese power market, by contrast, is extremely regulated in many aspects. The top Chinese official body in economic planning, the National Development and Reform Committee (NDRC) determines the wholesale price at which power producer can sell to the grid, and also the end-user price schedule at which the grid can sell to end-users in various categories (such as industrial, residential, special enterprises etc.). NDRC set the price schedule in coordination with the price bureaus in local provinces, attempting to balance the interest between various interest parties. This, however, has been proved a never-easy task. Power producers argue for high wholesale tariffs for sufficient margins to maintain generation and new investment. Grid companies lobby that huge investment on constructing national and regional transmission network need to be backed by enough margins from the spread between end-user and wholesale price. Local provincial officials, stress that low power prices is fundamental for local industrial development and residential power consumption (Daniel H. Rosen, 2007). Thus, the pricing in the power market is extremely complicated, involving factors as fuel price volatilities, politics, and economic cycles.

Figure 6.1 provides one of the many evidences that the current market structure and pricing regime of the Chinese power market is very sub-optimal. While the spot and forward contract prices of coal negotiated at market rates, NDRC set a cost pass-through regime for power producers in which 75% of coal price increase should be recovered by the corresponding amount raise in electricity rates. However, in reality, such regime has not been realized as expected. Figure 6.1 shows that since the beginning of 2004 electricity price only rise around 20% on average of the coal price increase. The power producers hence operated at a loss[13]. (Daniel H. Rosen, 2007)

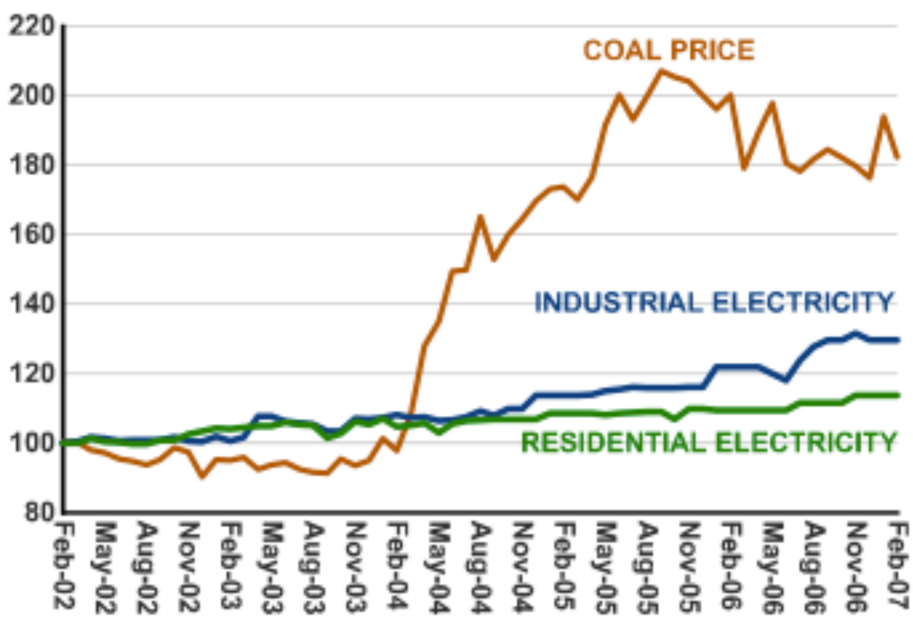

Figure 6.1 Historical Coal and Electricity Price Index

Source: (Daniel H. Rosen, 2007)

[13] In the case of high coal price, a rational decision for the power producer would be to stop operation. However, many power producers were required to produce.

When carbon price is incorporated as part of the cost for power generation, a similar dynamic is likely to occur between carbon cost and power wholesale prices, causing an unhealthy gap between the coal price and controlled power price. In the first three-year trial period, the carbon price volatility has a limited influence on the profit of power producers, because the allowances are allocated for free and according to official news the allowances will be allocated at sufficient level to cover emissions. The allowances might actually be a source of profit for power generators since they can sell unused allowances, which will be allocated for free, to producers who want to produce more or to the regulator at the end of each year in the trial period.

To maximize the utility of emission trading, the regulated power price is an issue that needs to address, in progress with the implementation of ETS. The deregulation of electricity market is complex task in China. The short-term practical solution would be a price regime that also includes the pass-through of carbon cost.

6.2. Underdeveloped forward market

As discussed in session 4.1, in the trial phase China would only allow spot carbon permits trading. The obvious reason is the underdeveloped forward markets in China. This is a fundamental difference between China and EU. Since the launch of EU ETS in 2005, several European exchanges quickly introduced forward products related to carbon allowances trading. The exchanges include the Intercontinental Exchange (ICE), European Climate Exchange (ECX), Bluenext, Nordpool and so on. The products include futures and forwards written on Phase I and Phase II EUAs, where the delivery date is normally in December or March.

A forward market has several benefits. First, it allows regulated companies to hedge their carbon exposure and hence reduce the risks in compliance. When holding a position in a forward market, companies are able to lock in the carbon prices, and the gaining from the hedge offsets the high carbon price. Second, the forward price has the effect as a price indication. Companies who are interested in investing in carbon mitigation technologies reply on such a price signal to make investment decision. In addition, the price influences the power producers to make operational decision. If power producers expect high forward carbon price, they would switch their production to technologies that emit less carbon, such as switch from coal to gas. Last but not least, forward carbon price is an important empirical source for research on carbon markets.

If only allow spot trading, the signaling effect of carbon prices is limited, i.e. companies could not make their decision based on forward carbon prices, and cannot hedge the future exposure via forward markets.

Part 3: Lessons from EU

Part 3 focuses on the most relevant lessons for China from the EU in starting and implementing the ETS. The lessons cover the aspects of infrastructure building for ETS and key policy design in cap-setting, allocation, sector coverage and some supplementary regulation to facilitate the functionality of carbon market. Each chapter in Part 3 starts with introducing the policy design and experience of EU ETS regards to the specific lesson, and goes further with relating the lessons to China's circumstances.

7. The pre-conditions: Emission data and projection

During the allocation stage, the EU member states encountered problems of lack of emission data. With a long history of industrialization and technology development, most EU member states have good quality emission data. The issue is, however, the difficulty in obtaining emission data at the installation-level. Even countries like Germany and Sweden had problems attaining installation-level emission data. Even though some member states were able to submit the data, the big discrepancies between earlier submitted data and the final version indicated the limited quality of the data. Denmark was the only member state that did not have such a problem since a carbon emission-trading scheme was already implemented. (Barbara Buchner, 2006)

Therefore, the EU governments had no choice but to rely on the data submitted from installations. Although the covered companies had been very coordinated with the member state governments in collecting emission data, the problem was the interest of the emitters to over-estimate their emission to be granted more allowances. This might also be one of the reasons for the over-allocation occurred in the first phase of EU ETS. Another consequence due to the limitation of data availability was to determine caps based on recent emission, rather than earlier historical emission. For example, German preferred to cap and allocate based on 1990 emissions, in order to be more consistent with Kyoto Protocol. This proved to be non-feasible since it was almost impossible to retrieve installation-level emission data from 1990.

A sub-sequential problem following data limitation is the difficulty in emission projection. Without sufficient historical coverage and quality of installation-level data, the projection on installation-level emission. The main purpose for EU to perform projection is to have a reference for determining national and sector total allocation. Projection became particularly difficult in industrial sectors, where a high degree of heterogeneity exits due to the varieties of products, inputs, factories, and technologies used in production lines.

The problem of data availability and projection difficulty is very likely to happen in China as well, since available emission data is probably less than the EU. In terms of data availability, China has good quality of energy consumption data of firms, enabling calculation of good approximations of aggregated emission. Good quality data on energy consumption and industrial inputs is available from the state-owned enterprises. These enterprises started the process of energy consumption monitoring and environmental pollution monitoring at a very early stage, as they were mandated to report energy usage to the central government or ministries to prove their achievements in energy consumption control and energy efficiency improvement. However, tone cannot expect similar availability of emission data on installation level. The mandate on energy consumption control and efficiency improvement is normally allocated on firm level.

Facing this problem, the first practical approach for the Chinese pilots is to follow EU's experience to rely more on most recent emission data. A second approach, which seems to be used already, is to allocate permits on a higher level instead of at the installation level. In the trial phase, the pilots can allocate the permits based on the most recent emissions from each firm affected by the scheme. The shortcoming of allocating at the firm level is that companies might leak its emission to installations outside the scheme. Yet this approach simplifies the long process of collecting data from installations, and avoids the need to rely on installation-level emission data with quality that cannot be guaranteed.

In terms of emission projection, although the projection itself is involves the complexity in methodology selection, inputs gathering, model calibration, assumptions validation, the lessons from EU ETS suggest projection is nevertheless necessary to ensure the functionality of ETS. The lessons are also applicable to China. First, projection of pilots' total emission introduces the top-down discipline to control the tendency of over-estimated aggregation of emissions in the button-up process (Barbara Buchner, 2006). An independent projection provides another reference to reconcile total emission with the sum of firm's total. Second, projections give the range of BAU emissions, and the reference to estimate the likelihood of over-allocation (Barbara Buchner, 2006). In these regards, projection is fundamental in designing emission-trading scheme.

To mitigate the negative impact due to the big bias between projected and actual emission, the first solution is to use a rather conservative estimate. However, given the great dynamics in the Chinese economy, especially rapid process of urbanization and industrial transformation, a projection over a long horizon is not practical. This was demonstrated in Chapter 1: none of the world's best energy research institutes have succeeded in providing a close emission forecast for China. A more practical alternative is to shorten the projection horizon to next or next 2-3 years. This implicitly assumes that the allocation occur more frequent than EU ETS. Rather than allocating for the whole trading period, the pilots can allocate permits over the next year, based on the previous year's emission and the most recent projection. By doing this, the impact of biased projection against actual emission is controlled: it can only influence next year, after which the bias would be corrected. As emission data improves and emission forecast knowledge accumulates, the pilots can extend the projection period to a longer horizon, or include more policy flexibilities to control the impact of projection bias.

8. Cap-setting and avoiding over-supply

Cap-setting

How EU ETS determined the proper amount of emission allowances is a valuable lesson for the pilots when designing their ETS. A properly set cap is fundamental in any cap and trading system. On one hand, a cap should have a binding effect that ensures the emission reduction efforts. The cap should be lower than BAU emission. If the cap is too modest no extra means are needed to mitigate the emission, neither will there be demand for purchasing allowances. At the end, prices will crash and resulting in a very negative influence on emission mitigation related investments. On the other hand, if the cap is set unrealistically tight that requires huge cost to reach, the economic activities would be imposed with a heavy burden.

During the first phase of EU ETS (2005-2007), member states proposed the national emission cap to the EU Commission, known as the national allocation plan (NAP). NAPs were generally based on business as usual emission forecast. In principle, the proposed cap should be in line with the member state's Kyoto targets. However, the caps were generally overestimated by member states. This was primarily due to the nature of the first phase as a trial period, where a lax cap was more acceptable by regulated companies. Also, the EU commission was influenced by lobbying and had inferior information (Steffen Brunner, 2008). In Phase I, covered installation received allowances for 2080 Mt CO2 on average per year, while actual emissions were 2020 Mt CO2 annually.

Over-allocation

In Phase I, banking and borrowing is not allowanced. For example, companies cannot store 2005 allowances for 2006 compliance. When verified 2005 emissions was published in April 2006, which was less than allocated allowances, the European Union Allowance (EUA) prices experienced a sharp fall, as represented by EUA Dec-07. Phase II also has a problem of over-allocation.

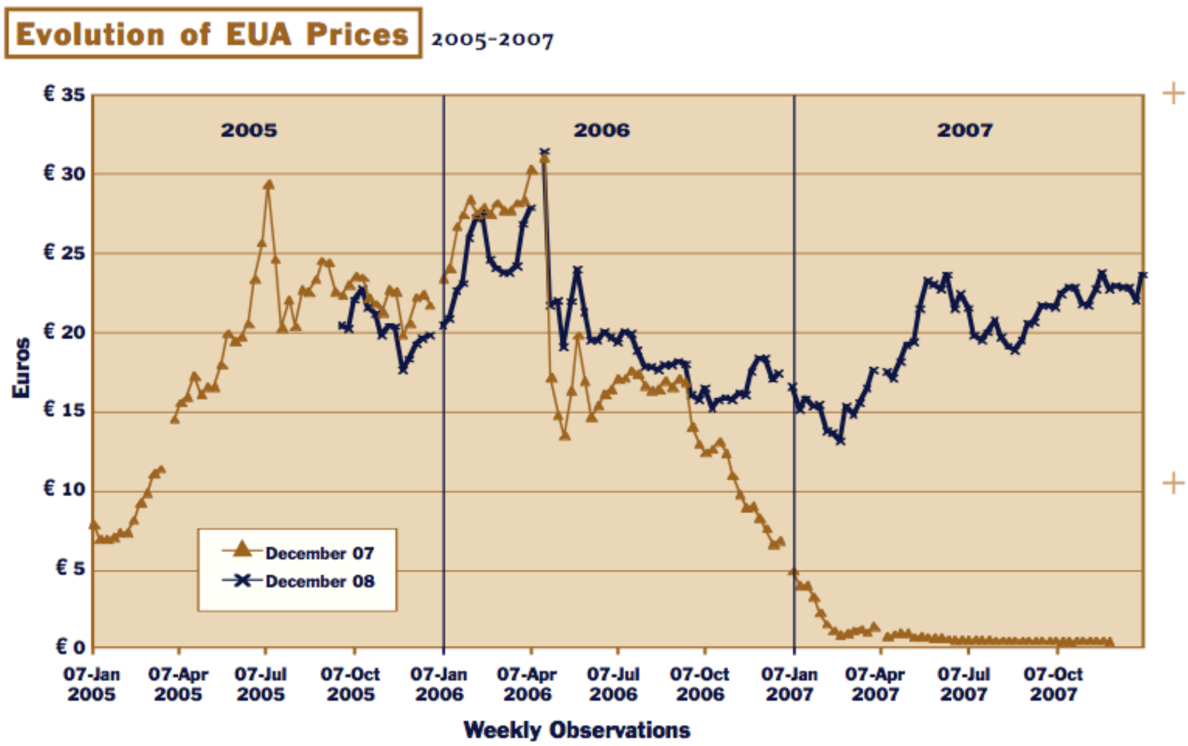

Figure 8.1 Evolution of EUA Prices 2005-2007

Source: (A. Denny Ellerman P. L., 2008)

The sharp decline of EUA Dec-07 contracts evidenced a controversy of EU ETS, known as over-allocation. Upon the end of the first phase, the EUA contracts for compliance, collapsed to close to zero. It shows that the cap-setting for the first phase was rather modest against the actual emissions. Ellerman (2007) analyzed several reasons: first is the modest cap against BAU emissions in the trial period. An emission cap becomes non-binding if the BAU emissions turned out to be over-estimated. Weather, economic growth, and post-adjusted emission estimation methodology, could alter he actual emissions against the BAU estimate. In the first phase of EU ETS, the deviation turned out to be on the low side. Second, determining the cap itself is a difficult task. Insufficient historical emission data, uncertainties in projection make the cap-setting uncertain by nature.

An efficient market should give clear and consistent price signal for investors. Extreme price volatility deteriorates investors' confidence and hence the functionality in crediting emission reduction is weakened. In the scenarios of low prices, companies with surplus emission allowances would suffer, especially companies whose allowance holdings occupies a large portion of their portfolio.

Lessons for China

What are the lessons for China, in order to avoid over-allocation? The ultimate solution is a sufficient tight cap that guarantees a binding effort to reduce emissions. However, as discussed earlier this is difficult in practice given the complexity in cap-setting and BAU emission projection, since it is almost impossible to represent all scenarios of economic growth, urbanization, industrial transformation in a rapid developing economy like China.

The first approach would be to increase the frequency of setting the cap. EU ETS mandates the cap for a period, known as “trading period”. The allowances allocated can be used for the compliance of all the emissions during the trading period. Therefore, the supply of allowances is static for that period once it is determined. The risk is then once the verified emissions in the early years indicated a low level; the supply cannot be adjusted to the actual demand, which is the actual below-estimated emission.

The Chinese pilots have chosen a different design. Hubei will set the cap on an annual basis. The key reference for setting the annual cap is emissions in the previous year. This introduces the flexibility of adjusting the supply with recent demand. I expect the supply will be adjusted to the demand in a positive correlated manner. I.e. increased supply next year if there is an indication that actual emission most likely is higher than projected, or reduces allocation if lower. The intention obviously is to avoid carbon prices being too high but also stabilize the prices from going dramatically down. Compared to setting the cap for the whole trading period, Hubei’s approach of annual cap setting has more capability in keeping the prices in the desired band.

However, the main limitation for this approach is it introduces political uncertainty. In EU ETS, the price of allowances is subject to economic uncertainties once the periodical cap is mandated.

The price of carbon is fundamentally related to the intensity of economic activities that generate emission. Whereas in Hubei's ETS, the price is dependent on the economic activities that determine the emission, but also the annual political decision which determines to what degree the cap next year would be adjusted to previous year's emission. A strong signal of stable or gradually increased carbon prices relies on strong and clear political commitment in guaranteeing a binding cap. This political uncertainty is a source of risk for investors, given the fast dynamic and complexity of Chinese political system.

In the case of EU ETS, such political uncertainty is reflected in the way that the commitment to ETS in a member state might alter when a new ruling party takes over. A ruling party, which set industrial development at a higher priority, might reject any proposals to keep up the carbon price. In China, although there is only one ruling party, the commitment on pre-defined political goals might differ when a new local governor takes over. The new governor might interpret the policy from the central government in a different way than the precedent. To eliminate the impact on ETS from the political uncertainty, the pilot schemes need to make clear political statement, especially on to what extent the scheme aims to keep the carbon price stable. Such statement could be 1) the promise to guarantee a price floor for the carbon price, or 2) a limitation on the extent to which the local government and adjust the annual cap. A firm political commitment protects the investment on carbon mitigation technologies and hence is a fundamental element of the functionality of a carbon market. Since 2012, the EU ETS experienced record low EUA price. Several proposals have been raised to the European Commission on how to rescue the EU ETS and boost the price to a sufficiently high level. However all proposals in favor of the EU ETS were all rejected, influenced by lobbying from industrial groups. As a consequence, the carbon price became very low, the coal production increased to a high level and companies who made investment on clean energy source were hurt deeply. For example, companies who invested in gas power plants experienced a huge loss as the gas power plant is not profitable to operate with a sufficiently high carbon price.

Hubei also introduces a unique regulation: companies must sell surplus permits each year, and at the end of the first three-year trial period, all unused permits are cancelled. One possible intention for forced sales of surplus permits each year is to avoid speculation on permits prices across time. When forcing sale of permits, companies with surplus permits can profit only at the prices in the current year. They cannot bank permits to the following year with a speculative intention to sell the permits at higher price next year, or reduce the cost by avoiding purchasing permits in the following year if the price are expected to be more expensive. This encourages companies to either fully use the permits or sell at highest possible price with the year. This also helps in stabilizing the price: banking permits to next year increases the supply, if not over-supply, to next year.

The second approach is another form of governmental-intervention into the market: set a price floor for the permits. The advantage is it guarantees the minimum price of permit, reducing the risk of investing in emission mitigation. Therefore, the downside of revenue is limited. The revenue is still subject to risk in demand, i.e. not buyers of permits. The disadvantage of price floors is, however, the elimination of competition. According to economic theory, a price control distorts market efficiency, i.e. the capability of the market to reach the optimal equilibrium at the market price. In reality, the practice of this theory is witnessed in the form that once the price reaches the price floor, price itself is not a determinant of competition advantage anymore. Instead, forms such as unfair access, bribery might become the competitive advantages in permits trading.

9. Avoiding windfall profits

The dynamics between carbon and power prices

In the Chinese regulated electricity market, without any regulatory adjustment, the cost of carbon is not passed on to wholesale prices. As a result, the value of allowances would not be passed through to end-users. The Chinese regulated market assumes a fixed margin over the fuel costs and operation cost. The effect of allowances, if distributed for free, occurs as an opportunity cost to the generators. Generators will not choose to produce if the market value of allowances rises to the extent that it is more profitable not to produce.

In a liberalized electricity market, wholesale prices equal the marginal cost of the generator that clears the market. The market value of the allowances will be included in the wholesale prices as the prices contain the cost of allowances of the marginal supplier. Nevertheless, in practice it is not likely that the carbon prices would be included completely in the wholesale power price, since the price could also be set by fuel cost.

Windfall profits in the EU ETS

During the first phase of the EU ETS (2005-2007), critics raised concerns about so-called "wind-fall profits". The controversy is such that power generators benefit from increased power prices that incorporate the allowances that are freely allocated. However, windfall profits itself is not a well-defined concept. Where does the profit come from? Who are the beneficiaries of the profits? Who bear the cost if the others gain the windfall profits? Is windfall profit fair? Or is it an issue that needs to be addressed in designing ETS?

First, where does the profit come from? In theory, when firms produce until marginal cost of increasing production equals price, mc(q,e)=p, where mc is marginal cost, q is output, e is permit costs. Assuming that mc at least increases with both output and permits, it must be the case that mc(q,e) – when q and e are positive, is larger than mc(q,0). The difference between mc(q,e) and mc(q,0) is the profit as a result of zero permit price. In other words, the windfall profits come from the fact that the wholesale power prices incorporate the permit price, while the allowances are allocated for free. Power generators will not benefit from the generation that needs extra allowances purchased from the market, because the increased wholesale prices are offset by the cost of allowances. The power companies that benefit the most are those with low marginal abatement cost. They would benefit from generation sold at higher prices and selling the extra non-used allowances. The benefits come from the companies that need to purchase allowances. For instance, a coal power producer with low cost flexibility to switch to gas-fired power would replace its coal-fired power generation with less CO2 intensive gas-fired power generation. It would hence benefit from higher wholesale prices and the sales of extra allowances because of using gas-fired power, as long as the gas prices is low enough and carbon prices is high enough to ensure margin over the abatement cost.

The example of switching coal-fired power to gas-fired power follows the principle of ETS: incentivizing the use of low-carbon technologies. However, the unfair aspect of windfall profits is that power generators that do not implement abatement measures also benefit from higher wholesale prices. Assuming that higher wholesale prices can be quickly pass over to retailer prices, increases in wholesale prices would indicate higher cost for power users, especially the companies in the power-intensive sectors such as cement and steel. As a result, higher wholesale power prices mean that a pie of profit is transferred from those sectors to the power sectors, which is not the intention of emission trading.

Lessons for China

To tackle generating windfall profits from ETS, the EU commission will gradually increase the amount of allowances to be auctioned rather than grandfathered. In Phase III, the power sector will need to purchase all the allowances via auctioning. The percentage of auctioned allowances in other sectors will gradually increase from 20% in 2013 to 100% by 2020. Overall, some 60% of total allowances will be auctioned in 2013. Through auctioning the Commission expect to offset the profits from higher power prices by auction cost.

The nature of the Chinese power sector being highly regulated indicates different pattern of windfall profits to power generators with the implementation of ETS, if any. The power price in China is normally adjusted on a non-regular basis by NDRC. The primary consideration of the adjustment is fuel price. With carbon as a new source of cost for power generation, there is possibility that NDRC would adjust the power price to ensure the profitability of the power generators over the increased cost. The challenge though is that the regulatory adjustment is not optimal compared to if could prices were adjusted by the market itself. The ad-hoc price adjustment is often in delay after the fuel price increase. If the price is also adjusted upwards by incorporating carbon cost, windfall profits problem will occur in the Chinese schemes as well, as long as the allowances is grandfathered. As experienced by EU, the consequence of windfall profits is the rise of controversies against emission trading, and an unfair profit distribution where power generators benefit from selling at higher power price to other sectors without cost increases. The schemes indicate the possibility to use auction in the future. Like the EU, allocating emission permits for free has the benefits of gaining industrial acceptance. With this regards, in the early trial periods free allocation is not necessary a bad thing, if it facilitates launching the emission trading schemes smoothly.

10. Sector coverage and sectoral allocation

Academic studies have found that a wider coverage of emission trading scheme is more efficient, in terms of cost-effectiveness of emission reduction and market operation. Böhringer and Löschel (2005) find a higher degree of cost-effectiveness when the ETS coverage is economy-wide compared to the exclusion of certain sectors (Böhringer, 2005). Baron and Bygrave on the other hand argue that broad coverage increase the liquidity and efficiency of carbon markets. (Baron, 2002). These findings favoring a broad coverage are illustrated in Figure 8.1.

On the left hand side of the chart, some technologies have negative abatement cost. Including these technologies no only reduce carbon emission with a substantial amount, but also bring in economic benefits from the savings of consuming less energy. These technologies are however not necessarily included in reality, even though the adoption is profitable even without the support of emission trading. The existence of technological potential of negative abatement cost suggests that without legal binding constraints, the potential would not be exploited.

In the first and second trading period, the EU ETS did not include the building and transportation sectors, even though these sectors have huge and low-cost abatement potential. The primary reason is the difficulty in monitoring emission data of these two sectors. The sectors that were covered are mainly power and heat sectors, and heavy industrial sectors such as cement & lime, steel, aluminum, refineries, glass, pulp & paper. The EU ETS covers some 12,000 installations. The emissions are however rather concentrated: 60% of total emissions come from 7% of installations.

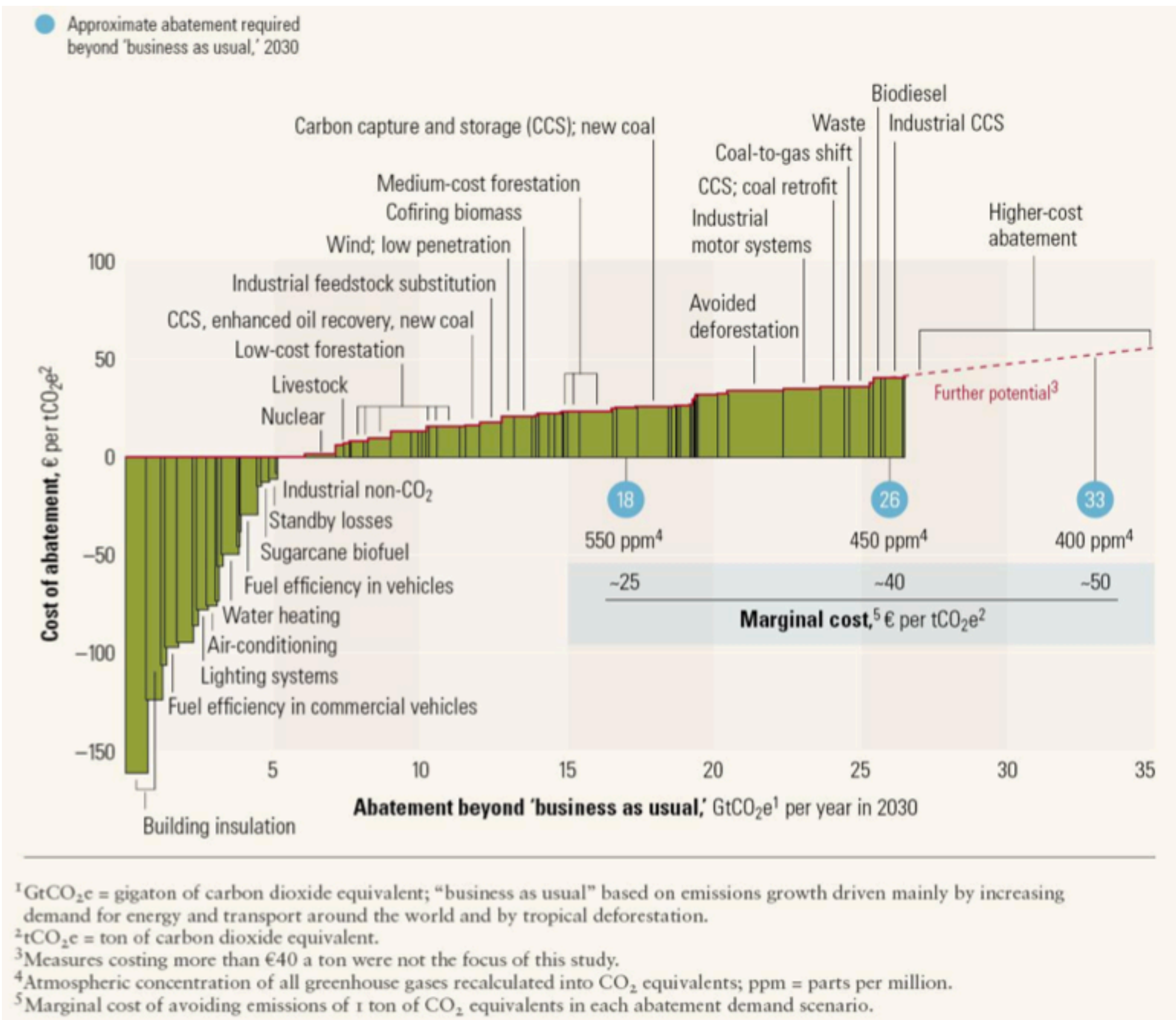

Figure 10.1 Cost curve for greenhouse gas reduction

Source: Mckinsey (2007)

The Chinese pilot schemes show some big differences compared to EU ETS, in terms of sector coverage. As shown in Table 4.1, three pilots (Beijing, Tianjin, Shanghai) intend to include building sectors into the scheme. This is in my view an improvement China made compared to the EU counterpart. With a high urbanization rate, building sectors emit a substantial amount in the three municipalities of Beijing, Tianjin, and Shanghai. Earlier, China has implemented several policy measures to incentivize energy efficiency improvements in large buildings in some Chinese major cities. A good track of energy consumption is available; therefore monitoring the emission is feasible by converting energy usage into emissions. Inclusion of low-abatement-cost sectors like building would shift down the abatement cost, as shown in Figure 8.1.

Regarding sectoral allocation, first phase of EU ETS witnessed large variation across sectors, in terms of net short/long position. It shows that the electricity sector as a whole is short, while all the industrial sectors are mostly long (A. Denny Ellerman B. K., 2007). This reflects the key consideration in sectoral allocation: generous treatment of sectors facing international competition, and achieving major mitigation from sectors only facing domestic competition.

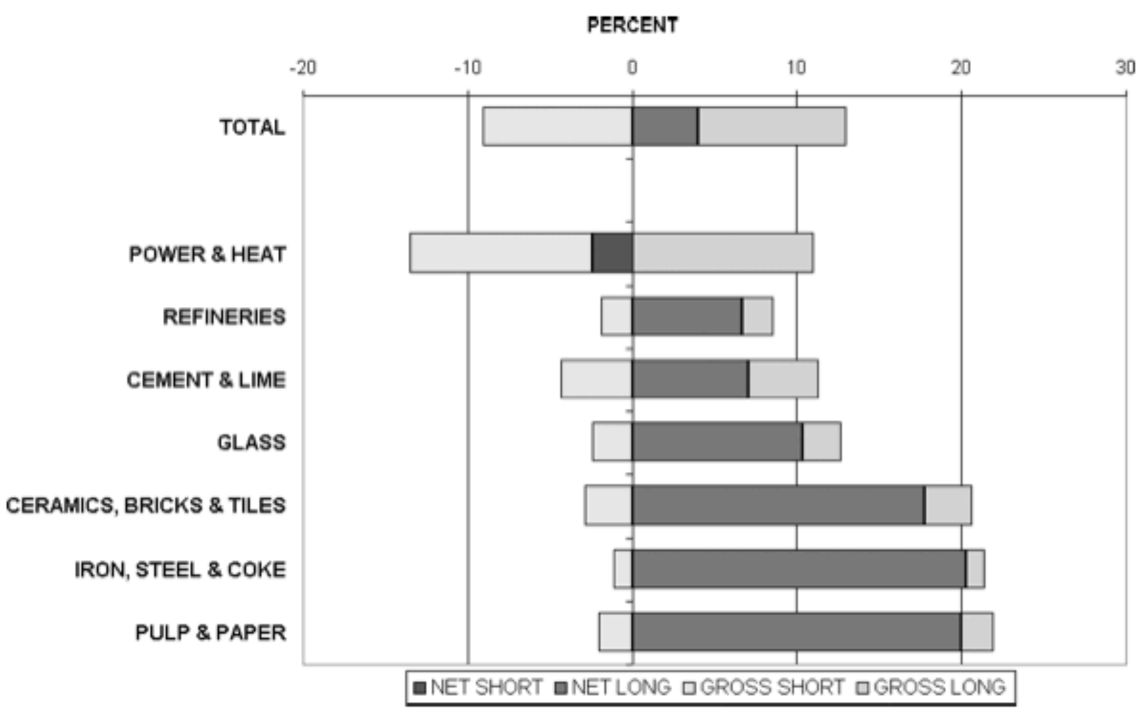

Figure 10.2 Short and long position by EU-Wide sectors

Source: (Barbara Buchner, 2006)

The similar pattern is expected from the Chinese pilot schemes as well. With economic development and high employment as the top priorities, it is unlikely that the pilot schemes will allocate strict caps on industrial sectors exposed to international competition. Compared to EU, this consideration is more important since the Chinese economy is highly export-oriented. Sectors like steel and cement rely heavily on foreign demand and compete at low margins. A high carbon cost could introduce economic shocks. The sectoral allocation could differ across pilots depending on the specific condition of the pilot scheme. A sector might have different abatement potential, as well as the pilots have different strategic interests in planning which sectors should be “cleaner”. The general principle is, nevertheless, to achieve the balance between imposing carbon cost and maintain sustainable economic growth.

11. New entrant reserve and close provision

The new entrant reserve and closer provision are two unique aspects in the EU ETS compared to previous cap and trade schemes. The new entrant reserve is namely to set aside a certain amount of allowances for installations built and operated after the trading period has started. The number of allowances for new entrant reserve is set to 195 million tons, or 3 percent of total cap (6500 Mt). However, the percentage of new entrant allowance in total allowances differs vastly between member states, from as much as 26 percent in Malta down to 0.4 percent in Poland (A. Denny Ellerman B. K., 2007).

The new entrant reserve is beneficial for the Chinese pilots to adopt. The new entrant reserve has two benefits. Firstly, by reserving a certain amount of allowances for the potential demand from new entrants introduce a higher certainty of supply-demand balance. Second, a correct treatment of new entrants ensures that the new installations compete with existing ones on equal terms. These two benefits might be more important for China, where rapid economic growth, industrial development is still going on. A fair amount of new power plants and factories will be built in relatively underdeveloped pilots like Hubei and Chongqing. Therefore, setting aside allowances for these potential new emitters is critical to ensure the balance of supply and demand of allowances.

However, the biggest challenge is the determination of allowance amount to be allocated to the new entrants. From the experience of EU, one should follow the principle of allocating allowances based on some benchmarks for a specific technology in a specific sector. The benchmark itself is usually based on some assessment of best practice or technology multiplied by expected production or new capacity (A. Denny Ellerman B. K., 2007). The methodology is however difficult to implement due to complexity in defining the benchmark. In the power sector for instance, defining the benchmark comprises of the categorization of installations in terms of fuels, technologies, history etc. To be more practical, China could initially limit allocating new entrant allowances to certain types of sectors, where the number of expected new entrants and technologies is clearer.

In contrast to the new entrant reserve, closure provision involves the decision on how the allowances allocated to installations that turned out to be closed should be treated. The use of closure provision is to incentivize companies not to close out and relocate their existing production (A. Denny Ellerman B. K., 2007). While the implementation of closure provision varies within the EU member states, the general principle is the retaining or transferring of the allowances from closed facility should be given to the facility that lies in the same member state. The key consideration of this principle is to avoid that companies move their production to places outside the schemes and at the same time benefit from extra allowances. This principle is also applicable in China. On one hand, this reduces the likelihood that companies covered by the schemes move their production to other regions of China that are not covered by the scheme. On the other hand, it avoids the carbon emission leaked from the pilots to places outside the scheme.

12. Bottom-level allocation: Benchmark or share of emission?

Benchmarking is a methodology to determine the allocation of emissions to individual installations. The allocation is based on a uniform emission rate adjusted with some index of historical activity or capacity. Despite the fact that benchmark is a relatively fair way to determine allocation, it is not widely used by EU member states (A. Denny Ellerman B. K., 2007). The main reason is heterogeneity between sectors and even within sectors. Especially the latter, because the benchmark for determining allocation for installations of a specific sector become particularly controversial if it is not fairly designed. The heterogeneity within a sector is primarily due to different production technologies and inputs. For instance, emissions from steel production differ greatly between blast furnace operation and electric arc furnace.

Due to the complexity of benchmarking, share of recent emission was chosen as the primary determinant of allocation instead. More specifically, the share refers to the installation's share of the sector's recent emissions, which is determined by some baseline period (A. Denny Ellerman B. K., 2007). The advantage of using the share of recent emission is primarily it is easy to implement. With available recent emission data, this approach significantly reduces the time and decision process compared to what would otherwise be spent on the selection and evaluation of a benchmark. Using share of recent emissions also place the installations in a position with easy-to-anticipate balance between supply and demand of allowances in the early trial years. If using benchmarks, an installation with high recent emissions might be allocated with very few allowances, therefore facing high compliance cost in the early years. Introducing the impact on business from sudden high compliance cost is not really the intention of ETS, which is rather to give a signal for long-term investments.

However, using share of recent emission is not fair to installations that adopted emission mitigation efforts before the scheme started. In principle those installations should be credited for their efforts. However, those installations would be allocated fewer allowances, reducing the potential revenue stream from emission trading. This problem is more likely to be amplified in China, where the emission-level and energy efficiency of installations vary vastly. China imposed various measures to eliminate inefficient and dirty industrial installations and power generators. However, there are still a large number of backward facilities. The degree of fairness by using recent emission share depends on the variety of companies.

China, on the one hand should consider allocating allowances based on share of recent emissions; on the other hand, China can adopt some practical solution to make the approach fairer.

13. Linkage and offsets

Linkage refers to using the credits from other carbon market for the compliance rather than using the permits from the system of its own. The EU ETS linked to the project-based Flexible Mechanisms under the Kyoto Protocol. In such way, the Certified Emission Reduction (CERs) units generated from Clean Development Mechanism (CDM) projects can be used for compliance under EU ETS; similar to CDM, is the Join Implementation, which generates Emission Reduction Units (ERUs) that can also be used in the EU ETS. The credits of CERs and ERU generated from Kyoto Protocol's Flexible Mechanisms are commonly generalized as offset credits or offsets.

The intention of linking EU ETS to other carbon markets is to exploit the low cost reduction alternative as much as possible. Since carbon emission is homogeneous, emission reduction occurring in different locations and through various technologies has the same effect on global warming. By linking to external carbon markets the EU is able to take advantages of low cost reduction means to achieve its commitment in emission reduction, as well as facilitate the support to developing countries in emission mitigation.

However, linking to CDM and JI brings controversies, which is primarily due to way the offset credits is generated and verified. As offset credits can be used in the EU ETS, this creates a significant demand for such credits. However, justifying those credits as "additional reduction" is difficult. Credits that truly indicate emission reduction should reflect the fact that such reduction is additional to the measures that are already taking place, otherwise the credits are merely “anyway tons” (A. Denny Ellerman P. L., 2008). Another controversy is the oversupply of CERs as well as the cheap cost in generating a CER from certain types of methodology. A typical example is the offsets from destruction of industrial gases such as HFC-23 and N2O. The controversial lies in the fact that although the cost for destroying the industrial gases is low, it does not create any social or environmental benefits. Instead, it creates perverse incentive to ramp up production from which the industrial gases as byproducts that can easily be destroyed.

The measures adopted by EU to tackle such problems from using offsets are to set quantitative limits on the extent to which offsets can be used: about 13% of the allocation. The EU also banned the use of offsets from industrial gases destruction. The intention is to avoid speculating on cheap offsets to replace necessary effort to abate the emission.

Linkage will take place in China as well. As shown in Table 13.1 every pilot allows the use of offset credits known as “China Certified Emission Reduction (CCER)”, and credits from forestry plantation. Except Shanghai, Shenzhen and Chongqing, all pilots set the quantitative limit from 5% up to 15%. The CCERs are credits from 52 emission reduction methodologies recognized by NDRC. These 52 methodologies generally originate from the CDM methodologies commonly used in the Chinese CDM projects. The revenue from selling CERs has declined dramatically with the record-low CERs price. As the outlook from EU ETS still remains bearish, the Chinese pilot schemes can become the new revenue source for the CDM projects in China. The projects can verify the credits as CCER and sell to the Chinese markets instead. In short, by using the existing CDM projects China is able to exploit the existing low cost abatement opportunities.

However, two controversies remain. The first is China allows the use of industrial gas offsets[14], which is banned in the EU ETS. The second is the over-supply of offset credits. By estimate HFCs,

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[14] Point Carbon Mar 2013, “China to allow HFC 23 offsets in domestic CO2 markets”, http://www.pointcarbon.com/news/1.2214345?date=20130311&sdtc=1

PFCs, and N2O reductions represent 71 per cent of offsets issued from the CDM projects, of which the main portion is in China[15]. Criticism focus on the risk that the use of cheap and over-supplied offsets might reduce the amount of actual emission reduction in the pilots, and it will deteriorate the incentive for the pilots to take effective efforts in mitigating emission.

Table 13.1 Use of Offset Credits in the Pilot Schemes

	Beijing	Tianjin	Shanghai	Guangdong	Shenzhen	Hubei	Chongqing
Offset quantitative limit	5 %	10 %	N/A	5-10 %	N/A	10-15 %	N/A
Offset criteria	CCERs, half in Beijing	CCERs	CCERs	CCERs, forestry	CCERs	CCERs projects within province, forestry	CCERs, forestry

Source: Point Carbon

However, I argue that these criticisms ignore the fact that the use of offsets is limited by a certain percentage of the allocation. In addition, allowing using industrial gas related offsets creates new demand for such credits as the demand from EU ETS no longer exists. Nevertheless, China should eliminate the risk of price depression from using offsets. In addition to quantitative limits, as the trading will be carried on in the future, the Chinese pilots should gradually reduce the use of cheap offsets. In the short run, China should also ensure the “Additionality” of offsets, especially the industrial gas related offsets, by imposing the restriction on building new production capacity that generates such gases. In the end, using cheap offsets is not in the strategic interest of China, as it does not incentivize advanced emission mitigation technologies.

[15] "UNEP Risoe CDM/JI Pipeline Analysis and Database". UNEP Risoe Centre. 2010-02-01. Retrieved 2010-02-22.

Part 4: Conclusion

14. Global implication of the Chinese ETS

Established in 2005, in 8 years, the EU ETS has evolved into the world's largest and most active carbon trading market, although the current low price indicates the market is in a crisis and needs fundamental reform. Nevertheless, the EU ETS sets an example that influences the establishment of carbon regime across the world. Following the EU, many countries adopt carbon trading schemes as a device to achieve their emission reduction targets, including South Korea, Japan, New Zealand, Australia and of course China. This is perhaps the biggest contribution from the EU ETS: facilitate the adoption of effective measures to tackle global warming.

After the cornerstone set by EU, what can the Chinese ETS bring? Firstly, establishing carbon trading market is a firm step further on mitigating domestic carbon emission. Tackling global warming is a mission impossible without China, the world's biggest emitter of greenhouse gases. When carbon trading becomes reality, it will strengthen China's image in committing to mitigate emissions. Lessons made by China would be valuable for developing countries to learn and adopt. If the Chinese market turns out to be successful, it will demonstrate that emission trading is a feasible approach for developing countries where economic development is naturally at a higher priority. The Chinese experience in carbon trading will demonstrate a new way of sustainable development to developing countries.

As the Chinese carbon trading schemes are being established, the emergence of a global carbon regime becomes clearer (there is already indications that the Chinese schemes will link to the Californian market[16]). A global carbon regime is the fundamental requirement to tackle global warming as it shows the global commitment and global efforts. With China being more involved

[16] Point Carbon May 2013, "U.N. says California and China in CO2 market link talks", http://www.pointcarbon.com/news/1.2393413?date=20130529&sdtc=1

in such a regime, countries like India, Brazil, and Russia are more likely to join and take firmer action in emission mitigation.

The above discussion relies on the optimistic outlook that the Chinese pilot carbon trading schemes will be successful. In contrast, if carbon trading turns out less effective than expected in China, the experience is also valuable. Fail in implementing effective carbon trading schemes in China will show the reasons why carbon trading is not applicable in countries like China. The reason might be the low degree of market liberalization, low transparency, over modest cap and so on. All the lessons are valuable to countries planning to establish ETS or the countries that plan to reform their domestic carbon markets.

15. Final conclusion

This paper assesses the seven Chinese carbon schemes being planned and implemented, and relates the relevant lessons from EU ETS to the Chinese circumstances. With 10% of the world's GDP, China accounts for 20% of global energy consumption and 25% of global CO_2 emission. The abatement potential is massive in China. With the 800 Mt CO_2 emissions covered, the seven Chinese pilot schemes are expected to be the world's second biggest carbon trading market in terms of covered emissions. Among the seven pilot areas, Guangdong is expected to have the highest carbon price, since this region must abate a large amount of emissions compared to BAU level to meet its emission intensity reduction target.

The Chinese schemes are similar to EU ETS in many ways, but also have their unique features. The Chinese schemes restrict emissions at the company level and the covered sectors are more diverse compared to EU ETS. By shortening the trading period to one year, the Chinese pilots have more political flexibilities to adjust the cap and maintain price stability. However, such regulatory flexibilities need to be backed by firm and clear political commitment to the carbon trading schemes. If China manages to keep its commitment to carbon trading and properly take political measures to maintain price stability, the Chinese schemes would be less likely to experience price crash than EU ETS.

Nevertheless, it is valuable for China to learn from the experience from the EU ETS. The general principles reflected from the EU ETS lessons are the importance in keeping price stability, ensuring the equality in permits trading, eliminating carbon leakage and last but not least, finding the right balance between ideal approaches and being practical. In the end, it is never possible to have a perfect start; getting started and correct the course along way make the EU ETS the world most successful carbon trading market.

Thirty years ago, the Chinese adopted capitalism but implemented it with “the Chinese Characteristics”, which led to a remarkably successful transformation in the country’s economic and social development. Now, China decides to use the carbon trading market to reduce its CO2 emissions in a cost-efficient manner. Again, the success of the carbon trading market will depend on whether China can adopt the western concept of emission trading and at the same time adapting emission trading to its unique environment.

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Appendix I: Inputs and Assumptions for Estimating Marginal Abatement Cost

The result from the Emission Projection and Policy Analysis model (EPPA) on estimating the Chinese marginal abatement cost:

Abatement ratio, % of gross emission	Marginal abatement cost, USD/ton CO2
10	9
20	24
30	45
40	72

Gao Pengfei's research finds that in the medium term the maximum abatement potential for China is 1600 Mt.

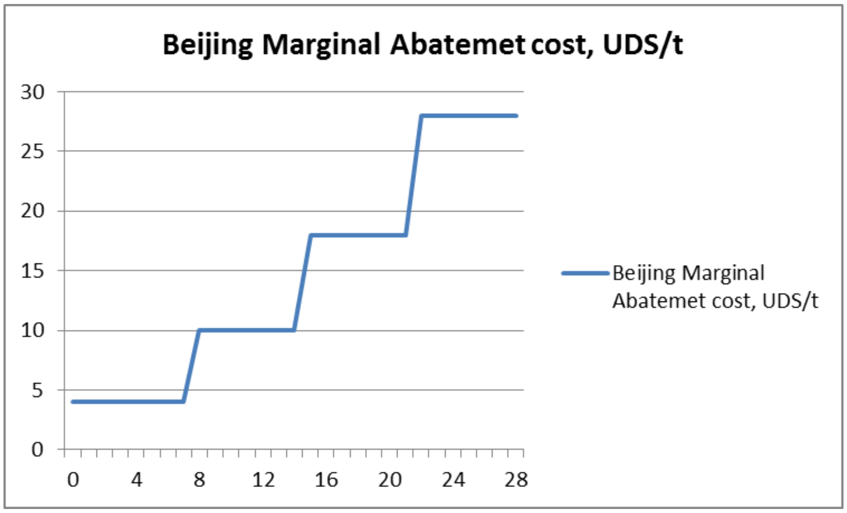
Based on the above research, to estimate the marginal abatement cost in each pilot area, I assume:

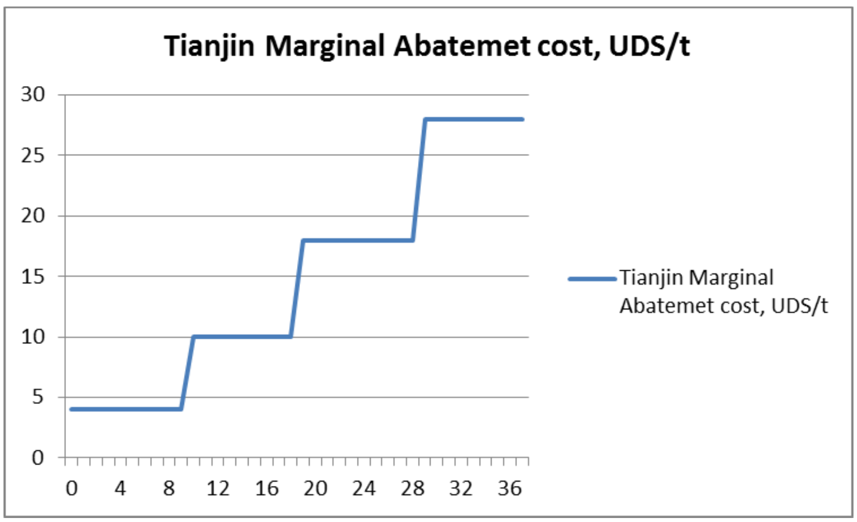
- The shape of marginal abatement cost curve of each pilot is the same as China. The only difference is the scale of abatement amount.
- The maximum abatement amount of each pilot is a percentage of the maximum abatement amount of China (1600 Mt). The percentage is the share of the pilot's emission in China's gross emission.

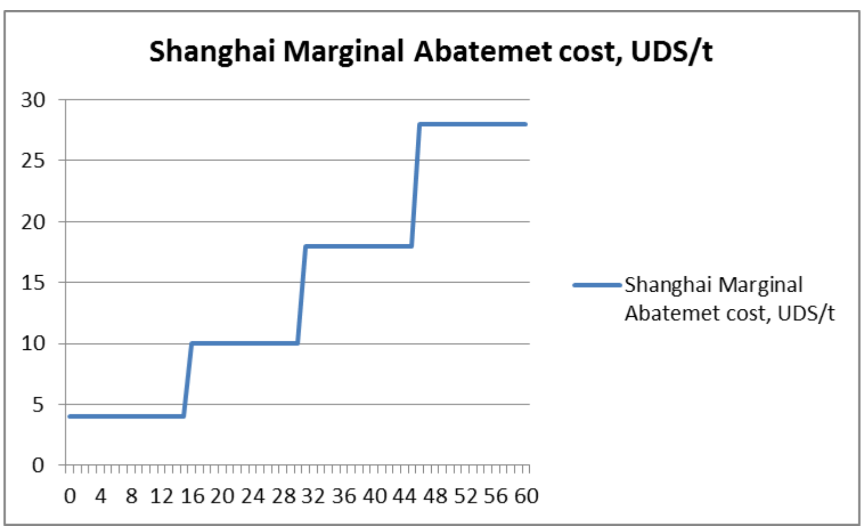
	China	Beijing	Tianjin	Shanghai	Guangdong	Hubei
2010 Emission, Mt CO2	6700	121	159	254	520	358
Share of emission	100%	2%	2%	4%	8%	5%
Abatement potential, Mt CO2	1600	29	38	61	124	85

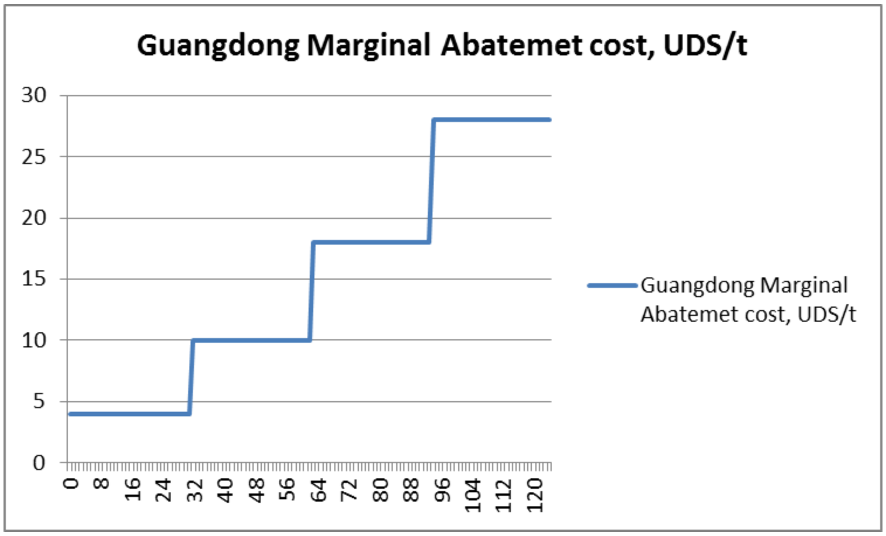
- If there is not expected abatement, the marginal cost is the minimum marginal cost on the curve.

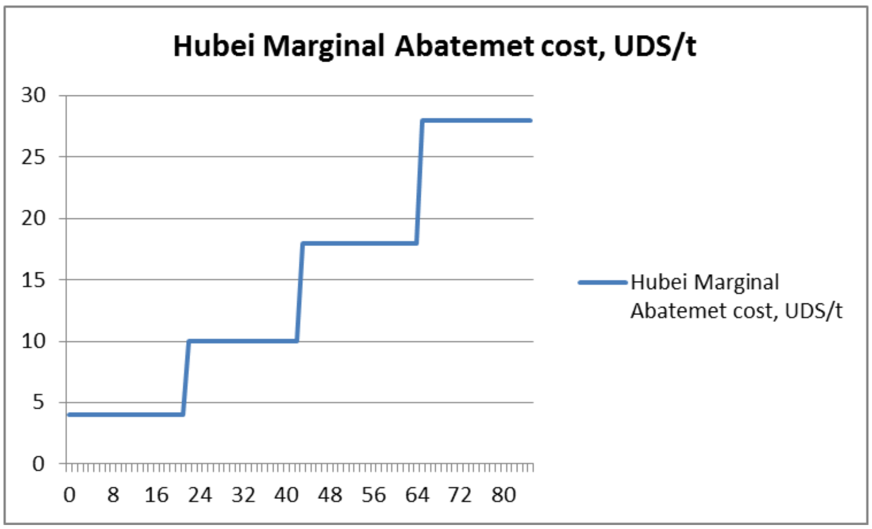
As a result, the marginal cost curve of each pilot is estimated as following:











With the expected abatement estimated as below (negative number means emission in 2015 is less than 2013 level):

	Expected abatement 2013-2015 , Mt CO2
Beijing	1.3
Tianjin	61.1
Shanghai	-41.7
Guangdong	-281.0
Hubei	-50.4

The marginal abatement cost in each pilot area is hence:

	Marginal abatement cost, USD/t
Beijing	4
Tianjin	4
Shanghai	18
Guangdong	28
Hubei	18