Emissions trading in China: Progress and prospects*

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Emissions trading in China: Progress and prospects

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HIGHLIGHTS

- We summarize the history of China's climate policy and milestones in China's ETS development.
- We provide a comprehensive overview of the current status of China's seven ETS pilots.
- We discuss some key issues and challenges related to the implementation of the ETS pilots.
- We identify next steps to support development of a national ETS in China.

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ABSTRACT

To control rising energy use and CO_2 emissions, China's leadership has enacted energy and CO_2 intensity targets as part of the Twelfth Five-Year Plan (the Twelfth FYP, 2011–2015). Both to support achievement of these targets and to lay the foundation for a future national market-based climate policy, at the end of 2011, China's government selected seven areas to establish pilot emissions trading systems (ETS). In this paper, we provide a comprehensive overview of current status of China's seven ETS pilots. Pilots differ in the extent of sectoral coverage, the size threshold for qualifying installations, and other design features that reflect diverse settings and priorities. By comparing the development of the ETS pilots, we identify issues that have emerged in the design process, and outline important next steps for the development of a national ETS.

1. Introduction

With the highest energy use and greenhouse gas emissions of any nation (International Energy Agency, 2012), China has begun to adopt comprehensive approaches to control its CO_2 emissions. At the end of 2011, policymakers announced plans to develop a domestic emissions trading system as a more cost-effective, market-based and internationally compatible mechanism for emissions reduction. As a step in this direction, the body responsible for climate change policy under China's State Council, the National Development and Reform Commission (NDRC), selected seven provinces and cities—Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong and Shenzhen—to establish pilot emissions trading systems (ETS) during the Twelfth Five-Year Plan (FYP) (National Development and Reform Commission, 2011).[1] The seven ETS pilots are required to launch before the end of 2013 and fully initiate trading by the end of 2015 (National Development and Reform Commission, 2011).

The NDRC has moved relatively quickly to establish the ETS pilots. The preparation and launch of the seven ETS pilots was set to take place in under three years (2011–2013). This is a short time frame considering that the EU-ETS was fully operational after more than seven years of preparation.[2] As China's ETS pilots begin to launch, there is great interest in understanding how each will develop and will compare to existing systems abroad.

This paper is organized as follows. In Section 2, we summarize the history of China's climate policy and milestones in China's ETS development. In Section 3, we provide a comprehensive overview of the current status and design of the seven ETS pilots, relying on news announcements, recent literature, and our own interviews. In Section 4, we discuss some key issues and challenges facing the implementation of an ETS in China. Section 5 offers conclusions and recommendations.

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[1] Beijing, Tianjin, Shanghai and Chongqing are municipal cities with the same status as provinces, and Hubei and Guangdong are provinces. Shenzhen is a city of Guangdong, but is also classified as a special economic zone.

[2] Measured from the time of publication of the report "Towards an EU Post-Kyoto Strategy" by European Commission in 1998 (European Commission, 1998) to the passage of legislation in 2003 (European Commission, 2003) and to the launch of EU-ETS Phase I Test Period in 2005, the EU took seven years to launch the EU-ETS.

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2. Background

Climate policy in China has the support of the country's top leadership. Premier Wen Jiabao's commitment to reduce national CO_2 emissions intensity by 40–45% by 2020 compared to 2005, announced at the 2009 Copenhagen climate talks (Xinhuanet, 2009), signaled a milestone in China's climate policy and prompted domestic efforts to design appropriate policies. China's recent steps to develop pilot emissions trading systems en route to a national system build on many years of experience with policies targeted at fossil energy use, including energy efficiency and conservation measures under previous Five-Year Plans and active participation in the Clean Development Mechanism under the Kyoto Protocol.

China has a long history of national policies targeting energy use. Historically, the country's Five-Year Plans have included national energy intensity targets. More recently, after decades of declining energy intensity, signs of reversal in this trend led the government to set binding targets for energy intensity reduction for the first time during the Eleventh Five-Year Plan (the Eleventh FYP, 2006–2010) (State Council, 2006). The target was disaggregated to different levels of government as well as to state-owned enterprises (SOEs), and target achievement was newly adopted as a component of performance evaluations for government officials and leaders of SOEs. These measures increased emphasis on improving systems for monitoring, reporting and verifying energy use. Under these policy initiatives, significant investment from the government promoted the diffusion of energy-saving technology and the growth of the energy performance contracting industry. During this period, the government relied heavily on command-and-control measures. To achieve compliance, over short periods a number of provinces forced large segments of industrial capacity to shut down as part of eleventh-hour efforts to meet the energy intensity targets (Lo and Wang, 2013). Observing the high and concentrated costs of such measures, policy makers have since increasingly focused on market-based measures such as an ETS to minimize the cost of achieving the Twelfth Five-Year Plan targets for reducing energy intensity and, for the first time, carbon intensity, in line with China's long term climate change policy goals.

China's experience with carbon markets dates to the introduction of the Clean Development Mechanism (CDM). In 2005, a regulation authorizing CDM participation originated with the support of the NDRC, Ministry of Science and Technology (MOST), Ministry of Foreign Affairs (MFA) and Ministry of Finance (MOF) (National Development and Reform Commission, 2005). By April 2012, China had become a dominant player in the CDM market with 51% of all registered CDM projects (Maraseni, 2013). By encouraging enterprises to document GHG savings and covert them to Certified Emission Reductions (CERs) for sale on international emissions exchanges, the CDM increased the familiarity of Chinese government officials, enterprises, and third-party verifiers with market-based mechanisms. In recent years, persistently low prices in the EU-ETS have made participation in the CDM far less attractive for project developers. However, the CDM has simultaneously established several key elements of a domestic carbon market. Fig. 1 provides an overview of developments in China's carbon policy, with emphasis on those paving the way for an ETS.

In terms of basic features, China's seven ETS pilots overlap and diverge in important ways. All are located in relatively developed regions with low emissions intensity compared to the national average. Most of them were previously selected as low-carbon development pilot areas (National Development and Reform Commission, 2010). At the same time, they represent a relatively large geographic distribution (as shown in Fig. 2), and differ in terms of economic scale, GDP per capita, and emissions per capita. To illustrate this diversity, we list some key indices in 2010 for the

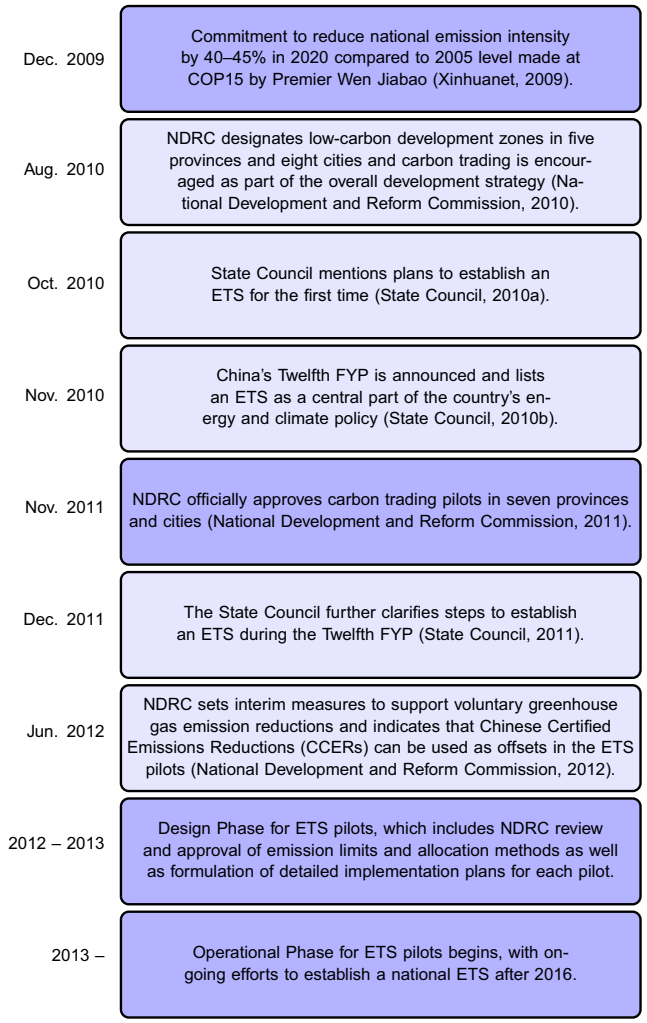

Fig. 1. Developments in China's ETS design in the context of national carbon policy (Xinhuanet, 2009; State Council, 2010a, 2010b, 2011; National Development and Reform Commission, 2011, 2012; State Council, 2011).

ETS pilots in Table 1. Table 1 also presents the aggregate targets for China and the EU-ETS as a point of comparison.

Based on the comparison in Table 1, we can see that most of the seven ETS pilots cover relatively affluent regions in China, and have higher per-capita GDP than the national average (Chongqing and Hubei are slightly below the national average). At the same time, most of their carbon intensities are lower than the national average, although there is still a more than twofold difference between the lowest (Shenzhen with 0.6 tCO_2/k$) and the highest (Hubei with 1.4 tCO_2/k$). CO_2 emissions per capita in each pilot also vary widely. However, emissions per capita in Hubei, Guangdong, and Chongqing are still relatively low. China has set national carbon intensity targets for 2015 and 2020 whereas Europe sets absolute targets (20% reduction in GHG emissions in 2020 compared to 2005). The share of coal consumption in China is high relative to the EU, contributing to the challenge of meeting the China's 2020 target.

3. Overview of China's ETS pilots

China's ETS pilots are in an early stage of development. While the NDRC has suggested that an absolute cap on national CO_2 emissions with trading across provinces is a long-term goal, the pilots are intended to build experience and identify challenges that should be resolved before moving to a national system. Pilot

Fig. 2. Location of the seven ETS pilots (shaded area with red boundaries) in China. (For interpretation of the references to color in this figure caption, the reader is referred to the online version of this paper.)

Table 1
Key indices in 2010 and policy targets for 2015 and 2020 with a comparison to the EU-27.

Region	Population (million)	GDP (Billion $)[a]	Total CO_2 emissions (Mton)	Per-capita GDP (1000$)	Per-capita CO_2 (t)	CO_2 intensity (t/1000$)	CO_2 intensity target for 2015 compared to 2010	CO_2 intensity target for 2020 compared to 2005
China	1337	5931	8900	4.4	6.7	1.5	−17.0%	−40% to −45%
Beijing	19.6	208	157	10.6	8.0	0.8	−18.0%	–
Tianjin	13.0	136	133	10.5	10.3	1.0	−19.0%	–
Shanghai	23.0	254	219	11.0	9.5	0.9	−19.0%	–
Chongqing	28.9	117	168	4.1	5.8	1.4	−17.0%	–
Hubei	57.2	236	250	4.1	4.4	1.1	−17.0%	–
Guangdong	104.3	680	522	5.0	5.3	0.8	−19.5%	–
Shenzhen	10.4	140	84	13.5	8.1	0.6	−21.0%	–
EU-27	502	16,176.2	3910	32.2	7.8	0.2	–	−20%[b]

Source: Xinhuanet (2009), National Statistics Bureau (2011a), National Statistics Bureau (2011b), Guangdong Statistics Bureau (2011), State Council (2012), People's Government of Guangdong Province (2012), Li (2013), Ge (2013), European Commission (2003, 2012), Agency PBL Netherlands Environmental Assessment (2012), The World Bank (2013), and UNFCCC (2013).

[a] Exchange rate in 2010: 1 US $=6.77 yuan=0.75€.

[b] This is an absolute target that is equivalent to an intensity target if and only if GDP remains constant over the period 2005–2020.

trading systems are also intended to support the attainment of CO_2 intensity reduction goals under China's Twelfth FYP. These goals are assigned at the provincial level but are implemented through largely inflexible sector- and firm-level targets. By allowing trading between high and low marginal cost emitters, ETS pilots could lower the cost of meeting provincial targets.

Pilots ETS designs vary widely, reflecting diverse circumstances and priorities in the localities where they are implemented. In the rest of this section, we compare the design of China's ETS pilots and explore the rationale for these choices. Emissions coverage of the ETS pilots is summarized in Table 2.[3]

3.1. Size of the cap

Consistent with China's domestic climate policy approach, China's ETS pilots focus on CO_2, the major energy-related greenhouse gas.[4] The effective stringency of the caps on total CO_2 emissions varies across pilots. Pilots also differ in terms of the sectors included and emissions threshold used to determine whether an installation is covered or not. As shown in Table 2, ETS coverage ranges from 33% of emissions in Hubei to 60% in Tianjin. Covered emissions under all pilots amount to 7% of China's total emissions. Progress is likely to be assessed in relation to

[3] An important caveat here for this table and the rest part of the paper is that there are still many ongoing changes though we have made a concerted effort to collect up-to-date empirical information about the seven pilots.

[4] Emissions reductions under the EU-ETS and the CDM of the Kyoto Protocol target reductions in all greenhouse gases, with reductions measured in CO_2 equivalents converted at global warming potentials established by the IPCC.

Table 2
A comparison of emissions coverage under the ETS pilots (all values shown are for 2010).

Region	GHGs	Covered CO_2 emissions (Mton)	Share of total emissions	Direct or indirect emissions	Number of covered entities	Emissions threshold for coverage (tons CO_2/year)	Historical emissions period
Beijing	CO_2	58	50%	Direct and indirect	approx. 490	> 10,000 (average (stationary emissions))	2009–2012
Tianjin	CO_2	112	45%	Direct and indirect	197	> 20,000 for industry; > 10,000 for other sectors	2010–2011
Shanghai	CO_2	90	60%	Direct and indirect	191	> 20,000	2009–2012
Chongqing	CO_2	No data	Not yet available	Direct and indirect	No data	> 20,000 (or 10,000 tce)	2008–2010
Hubei	CO_2	117	33%	Direct and indirect	107	> Approx.120,000 (or 60,000 tce)	2010–2011
Guangdong	CO_2	209	42%	Direct and indirect	830	> 20,000 (or 10,000 tce)	2010–2012
Shenzhen	CO_2	32	40%	Direct and indirect	635	> 5000	2009–2011
All ETS pilots	CO_2	> 620	7% of China's total	Direct and indirect	> 2535		
EU-ETS (Phase I)	CO_2	2014	47%	Direct	11,500	> 10,000	1996–2004

Source: Duan (2013), International Carbon Action Partnership (ICAP) (2013), European Commission (2013), Qiu (2013), and Xu (2013).

existing regional CO_2 intensity targets. Absolute emissions reduction targets for each pilot area and for the nation as a whole have not yet been announced. Policy makers have indicated that an absolute cap may be announced in future years, perhaps as part of efforts to establish a national ETS.

3.2. Coverage of direct and indirect emissions

All seven ETS pilots cover both indirect and direct emissions (Shenzhen Development and Reform Commission, 2013; People's Government of Shanghai Municipal City, 2013; Beijing Development and Reform Commission, 2013; Zhang, 2013b). Direct emissions refer to emissions generated by activities located within the covered area/sector, while indirect emissions are external but linked to the use of goods in the covered area/sector. For instance, emissions linked to electricity used in the production of goods imported into the covered area would be considered as indirect. In some provinces, indirect emissions can account for a large share of total emissions, up to 80% in some cases (Feng et al., 2013). Therefore, all of the seven ETS pilots cover the indirect emissions from electricity (both generated within the pilot region and imported from other regions) as electricity is the major source of emissions associated with goods traded across provinces and measuring the quantity of electricity flows is relatively straightforward.

Another important consideration for including indirect emissions is that China's electricity price is regulated. Currently the price signal cannot be passed to electricity users. Therefore, indirect emissions accounting helps us to ensure that industrial users will have the incentive to reduce electricity use because the price they pay for electricity will include the cost of purchasing emissions permits associated with the electricity they use.

3.3. Coverage thresholds and number of covered entities

The total number of covered installations varies in each of the pilots from 107 in Hubei to 830 in Guangdong. This variation is due to the emissions threshold used to determine coverage, local composition of industry, and size of the covered area.[5] In particular, Hubei has a much higher threshold for inclusion (installations emitting more than 120,000 ton CO_2/year), while Shenzhen has the lowest (above 5000 ton CO_2/year) (Qi, 2013; Shenzhen Development and Reform Commission, 2013). A lower threshold in Shenzhen is more tolerable because the number of candidate entities is also lower, while in Hubei this number is much higher. All of the pilots include entities in a common subset of sectors: heat and electricity production, iron and steel, nonferrous metals, petrochemicals and chemicals, pulp and paper, and glass and cement. However, there are also some striking differences across pilots in terms of the sectors included. For example, Shenzhen covers road transportation, while Shanghai has announced that it will include aviation and has already identified six airlines as covered by its pilot scheme (4C Note, 2013). In Tianjin, the oil and gas exploration sector is included to account for emissions associated with the offshore Bohai Bay oil and gas development (Climate Connect, 2010). By requiring institutions to surrender permits based on building energy use, some pilots account for indirect emissions from building electricity and heating demand in the commercial sector (International Carbon Action Partnership (ICAP), 2013). Beijing will cover a total of over 40 different sectors (Zhang, 2013a). Table 3 shows the detailed sectoral coverage of each pilot.

Decisions of sectoral coverage and threshold selection are based on a balance of keeping a large share of emissions covered while maintaining a relatively manageable number of entities during the pilot phase of emissions trading. As described in Jotzo (2013), the broader the coverage of emission sources, the stronger the incentive to reduce overall emissions, but increasing coverage will also increase the administrative effort for government and the aggregate compliance costs to industry. Moreover, differences of threshold and number of covered entities between the pilots will also complicate efforts to establish a uniform national ETS in the future.

3.4. Initial allocation of emissions permits

The initial allocation of emissions permits affects how costs of meeting the reduction target are distributed, making it a sensitive area of discussion in each of the ETS pilots. Except for a small number of allowances auctioned in Guangdong (Xinhuanet, 2013) and potentially in Shenzhen (Shenzhen Development and Reform Commission, 2013), so far in the pilots virtually all permits are freely allocated based on historical emissions. One rationale given is that free allocation reduces the burden to the enterprises and thus has more limited impact on economic development, which is still a priority for local governments.[6] Historical emissions are based on only a few years of reporting due to limited available data

[5] Chongqing is omitted from this discussion as the data are not available.

[6] Benchmarking is used in Beijing, Shanghai and Shenzhen to inform allocations for some sectors. For more details on benchmarking in the Shenzhen ETS, see Jiang (2013).

Table 3
Sectoral coverage of the ETS pilots. N.A. - Not available.

	Manufacturing sectors covered	Other sectors covered	Covered in all systems
Beijing	17 Manufacturing industries	Commercial buildings, financial, hotel, restaurants, post, education, medical, retail, public utilities, etc.	Heat and electricity production, iron and steel, nonferrous metal, petrochemicals and chemical, pulp and paper, glass and cement
Tianjin	Oil and gas exploration	Buildings	
Shanghai	Textiles and building materials	Commercial buildings, financial, hotel, airlines, harbors, airports, railway, etc.	
Chongqing	N.A.	N.A.	
Hubei	Automobile	N.A.	
Guangdong	Textiles	Commercial buildings, transportation and construction (some of them may be included from 2015 onwards)	
Shenzhen	26 Manufacturing industries	Commercial buildings and transportation (under consideration)	

Source: Li (2013), Zhang (2013a), Sun (2013), Wu (2013), Qi (2013), Wang (2013).

on historical emissions and difficulties in corroborating reported emissions with energy use information. The allocation is established annually in the case of Beijing, Tianjin, Hubei, and Guangdong, while Shanghai and Shenzhen plan to issue allowances once at the beginning of the compliance period for 2013 to 2015 (Li, 2013).

Setting the allowance reserve for new entrants is an important consideration in the design of China's ETS pilots. The speed of economic growth, especially for less developed regions, e.g. Hubei and Chongqing, is still high, therefore, policymakers have set emissions targets that reflect expected increases in the level of economic activity. In some pilots, such as Hubei, new entrants will be covered under the ETS with allowance allocations based on emissions data from the first year of operation (Qi, 2013), while other pilots such as Shenzhen and Beijing will grant new entrants allowances based on benchmarking similar to current practices in the EU-ETS (Shenzhen Development and Reform Commission, 2013; Beijing Development and Reform Commission, 2013). In addition to maintaining a reserve for new entrants, the government will retain some allowances that can be bought and sold to ease short-term price pressure (Shenzhen Development and Reform Commission, 2013; People's Government of Shanghai Municipal City, 2013; Beijing Development and Reform Commission, 2013). The details of allowance reserve, e.g. size of reserve and triggering conditions had not yet been disclosed at the time this article was written.

3.5. Offsets

To encourage cost-effective measures in sectors and regions not directly covered by the ETS pilots, all pilots will accept offsets generated by Certified Emission Reduction projects in China. Chinese Certified Emissions Reductions (CCERs) are administered on a national basis. The first CCER deal was initiated by Beijing Exchange Beijing Environmental Exchange on November 28, 2013, with the volume of 10,000 ton CO_2 and price of 16 yuan/ton (People's Daily Online, 2013). The use of these offset credits will likely be restricted a limit of 10% of the total targeted reductions (Carbon Market Watch, 2013). In documents recently published by the Shenzhen, Shanghai and Beijing ETS pilots, the shares of offsets are 10%, 5% and 5% respectively (Shenzhen Development and Reform Commission, 2013; People's Government of Shanghai Municipal City, 2013; Beijing Development and Reform Commission, 2013). In addition to helping to reduce the cost of emissions reductions in pilot regions, CCERs are also expected to support the development of capacity to set up an ETS in non-covered provinces in the future.

3.6. Monitoring, reporting and verification (MRV)

The effectiveness of an emissions trading system hinges on sound procedures for monitoring, reporting, and verification (MRV). Design of MRV requirements and procedures is still in the early stages, with an electronic reporting and verification system currently under development. During the trial period, the design of procedures used by the pilots has relied on a range of sources and international experience (Li, 2013). In some cases, these efforts have culminated in the publication of provisional guidelines for monitoring and reporting of CO_2 emissions, which have been issued in both Shanghai (Wu, 2013) and Shenzhen (Ge, 2013). In an effort to strengthen reporting capabilities across both covered and non-covered sectors, uncovered enterprises with emissions that exceed thresholds for coverage in some pilots, e.g. Beijing, Shanghai, Guangdong and Shenzhen, are also required to report their emissions in each year (International Carbon Action Partnership (ICAP), 2013).

3.7. Emissions trading registries and market development

In order to track allowance holding, transfers, and cancellations, each pilot will have its own electronic registry. In many cases pilots have partnered with existing registries to develop the necessary systems. For example, the Tianjin Climate Exchange was established in 2008 by a partnership including PetroChina, the Chicago Climate Exchange, and the Tianjin Property Rights Exchange (Sun, 2013). These systems are being developed with an eye to the potential for scaling up to handle volumes that may result from a national trading system in the future. Only spot market transactions will be permitted under the ETS pilots, as financial institutions are currently not permitted to take part in the emissions trading market. All of the pilots permit banking of emissions permits but prohibit borrowing from future allocations (Li, 2013). By contrast, unlimited banking and borrowing was permitted under the first phase of the EU-ETS (International Energy Agency (IEA), 2010).

Launched pilots have already registered some carbon credit transactions. In June 2013, Shenzhen's carbon price ranged between RMB 28 and 30 ($4.60 to $4.90) per ton where 21 kton of emissions permits have been traded in the spot market at the China Shenzhen Emissions Exchange (Climate Bridge, 2013).

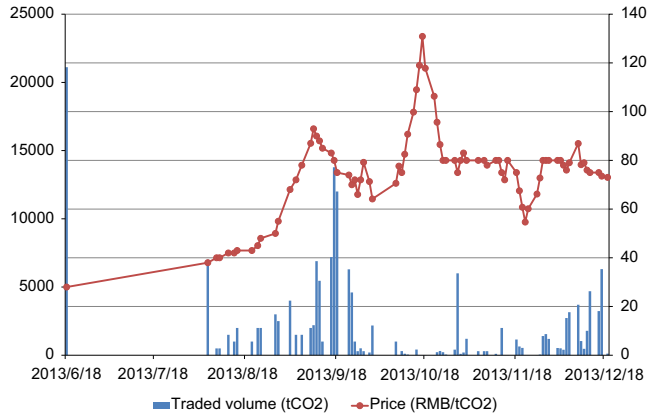

Fig. 3. Carbon prices (right axis) and traded volumes (left axis) in the Shenzhen ETS.

A survey of the carbon price of the Chinese pilots conducted after the launch of Shenzhen ETS (Jotzo et al., this issue) generated estimates of expected carbon price around RMB 30 (US $4.90) for the pilots, which is very close to Shanghai's carbon price in November 2013 (around RMB 27 (US $4.50)), while the carbon prices in Beijing (around RMB 50 (US $8.20)) and Shenzhen (around RMB 80 (US $13.10)) in November 2013 have already exceeded this forecast by a large margin (Xu, 2013; National Business Daily, 2013). We show the carbon prices and traded volumes of the Shenzhen ETS in Fig. 3. However, the prices are still below levels that researchers expect to be needed to achieve meaningful reductions consistent with the country's CO_2 intensity target (Zhang et al., 2013; Tang and Wu, 2013; Gu et al., 2013). Mechanisms such as a price floor and safety valve have been suggested by some ETS pilots (Shenzhen Development and Reform Commission, 2013; Qi and Wang, 2013), but none of the pilots has yet announced specific measures.

3.8. Enforcing compliance

Each year, covered enterprises will be required to surrender allowances for emissions at the beginning of the following year. Compliance requires that surrendered emissions allowances equal the verified level of emissions for each enterprise. For public utilities and SOEs, target achievement is now included as a measure of the performance of government officials and leaders of SOEs. However, the financial penalties for non-compliance are relatively low, especially from the perspective of covered entities under current rules, and these rules cannot be altered without changing China's existing laws. As a result, some pilots are trying to create other incentives for compliance. Tianjin will prevent non-compliant enterprises from enjoying the benefits of preferential policies such as low-interest loans (Sun, 2013). Shenzhen has announced detailed penalty rules, for instance, the shortfall of allowances in one year will be deducted from the allowance allocation in the next year, and the penalty will be equivalent to the shortfall multiplied times triple the average allowance price in last six months. A penalty of less than 100,000 yuan per unit can further be levied for other illegal actions taken in the course of ETS participation. In addition, bonuses will be provided to enterprises that undertake additional emissions reductions and surrender permits in excess of their allocated emissions. (Shenzhen Development and Reform Commission, 2013).

Beijing has also recently announced several measures to support compliance (Beijing Development and Reform Commission, 2013; Zhang, 2013a). Non-compliant enterprises will be required to pay the equivalent value of three to five times their emissions shortfall at the prevailing carbon price. The shortfall will also be added to the emissions reduction target for the following year. Several additional measures further discourage non-compliance. First, non-compliant enterprises lose access to government energy conservation funds. Second, non-compliant entities are not be eligible to apply for energy efficiency subsidies from the Beijing government, while the review of applications for new investments that do not pass an energy efficiency assessment will be delayed. Third, non-compliance will result in a downgrading of the entity's credit rating, affecting access to credit. Taken together, this combination of economic and regulatory penalties is intended to strongly discourage non-compliance.

4. Challenges for future national ETS design and implementation

Most of China's ETS pilots are still in the design phase. Even after trading in the pilots formally begins, ETS designs are likely to require adjustment as unforeseen challenges are identified and addressed. Looking to the future, the pilots are a first step towards a national ETS. Before a national ETS can be established, however, policymakers must first face several important challenges.

4.1. Legal and regulatory barriers

First of all, there is so far no clear legal mandate for establishing an ETS at the national level. A national law is important because without it, provinces do not have legal grounds to initiate the local legislation needed to establish an emissions trading system. Moreover, a national mandate would provide uniform guidance across provinces, ensuring system-wide compatibility. National law in China supersedes local law. In the absence of national law, provinces will have little incentive to coordinate their activities. By providing a legal framework, a national mandate, such as a national law on climate change, would allow provinces to move more quickly to develop ETS institutions compatible with a national trading system.

Second, at present certain types of financial exchanges, including those that would be needed to efficiently handle a national permit trading system, are prohibited by the existing Regulation on Financial Derivatives Exchange. Currently carbon permit trading can only occur between one buyer and one seller or one buyer and multiple sellers, rather than through continuous trades among multiple buyers and multiple sellers (i.e. through a centralized exchange). To remedy this challenge, the government would need to grant explicit permission for trading carbon emissions rights in exchanges.

Third, mechanisms for enforcing compliance with an ETS are still weak in China. The current allowable fine of up to 100,000 yuan per enterprise does not provide a strong deterrent against non-compliance. Under recently amended law, offenders can be punished severely for environmental pollution. For instance, fines may be much higher, or offending entities can be forced to close down. An important challenge is to extend a similar treatment to carbon, providing a more powerful incentive for covered entities to comply under a national ETS.

4.2. Interactions with existing energy and climate policy

At present multiple ministries and agencies are involved in setting regulations to manage energy use, especially as it relates to energy security, climate change, and air quality outcomes. These regulations include detailed targets set at the national and provincial levels. They also impose specific requirements on local governments and firms. The large number of regulations originating from different parts of the government increases the chances of inconsistency and overlap, potentially causing confusion and reducing effectiveness. Currently there are a wide range of sectoral

measures to promote low carbon technologies and energy efficiency, as well as other national policies to manage coal and petroleum consumption, and these will interact with a national ETS. For example, existing renewable energy policies will deliver some of the reductions required by an ETS, and so the carbon price needed to incentivize the remaining reductions to meet the ETS cap will be lower. Therefore, it will be important to develop mechanisms for coordinating policy across multiple agencies—for example, by minimizing overlap between sectors covered by the ETS and those subject to direct regulation.

Similarly, there is also a need to decide on the primary target of regulations. Energy has been tracked and subject to intensity targets for decades, while intensity targets for carbon are relatively recent, starting with the beginning of the Twelfth Five-Year Plan in 2011. Whether energy or carbon will be the basis of a new comprehensive regulation on climate change remains an open question, given that both a cap on coal and an ETS for carbon have been proposed.

4.3. Equity considerations under a national ETS

The development of a national ETS will also require steps to facilitate trade in carbon permits and to address associated equity considerations. First, national ETS will require consensus on the number, location, and function of carbon exchanges that facilitate trades across provinces. It has not yet been decided whether exchanges will be set up and managed in each province or located in one or a few major financial centers. How this authority is distributed is an important concern of government officials involved in the design of China's trading system. Watchdog institutions will also be needed to monitor trading once the exchanges have been established.

A second essential consideration still under discussion is the criteria that will be used to allocate emissions rights (permits) among provinces (and/or industries). Currently China's carbon intensity targets are assigned at the level of both provinces and industries, although these two sets of targets are only loosely coordinated. Under an ETS, the initial allocation of permits across the economy will determine how the costs are distributed. Virtually any criteria could be used to allocate permits but each will produce a unique outcome, each of which favors different interests—for example, allocation approaches could favor provinces with low total emissions, low emissions per capita, low emissions intensity per unit of GDP, a high population, and so on. China's central and western provinces are generally less developed than the more urbanized and populous east. The center and west are also resource rich, relative to other parts of the country. Allocating permits disproportionately to the center and west, which also offer many of the low-cost abatement opportunities, would facilitate a transfer of wealth westward and offset the costs of significant, cost-effective abatement. Resolving the question of which metric or metrics will be used to allocate emissions rights will be an important step toward mobilizing provincial and industry support for a national ETS. A possible step towards building a national emissions market may involve linking together the ETS pilots, with the eventual extension to an ever greater number of provinces. Clearly signaling that linkages are a step towards a full national system will be important, and accelerating the linking process will reduce the risk of leakage. Building a national ETS in China is very important, given that production and consumption activities span provincial borders. Measures to control carbon at the borders of trading areas are likely to be blunt and imperfect, while a much more cost-effective solution involves broadening ETS coverage. However, as academic studies and experience increase confidence in the likely consequences of future ETS expansion, pilots may begin to experiment with domestic linkages (Liu et al., 2013). Over the long term successfully establishing a robust trading system in China will make it an obvious candidate for inclusion in an expanded international trading system.

4.4. Monitoring, reporting, and verification under a national ETS

A final important step towards a national ETS will involve the continued development and coordination of energy use and emissions inventories, as well as the ongoing monitoring of firm compliance. Many entities have not yet established emissions inventories, and the pace of developing these inventories varies across industries and provinces. Harmonized national guidelines for inventory preparation will need to be established. Independent verification of annual emissions reporting will also need to be established in order to raise the credibility of the new system and support linkages with other ETS initiatives around the world.

5. Conclusion

China is still in the early phases of ETS development. Current efforts are building on a history of participation in the Clean Development Mechanism, decades of energy intensity management, and a strong commitment at the national level to addressing global climate change. The ETS pilots are an important part of this broader commitment. While by themselves the pilots are not anticipated to significantly impact the country's energy use and emissions, they form an important experiment and learning opportunity that will shape a potential future national ETS. Setting up ETS pilots also reflects the spirit of *shidian* (pilot projects/policies that are implemented in part of the country before a national law is drafted), which is a well-recognized concept applied in the policy making process in China. By choosing regions with different features for policy experiments, pilot programs can help policy makers to avoid risks associated with direct implementation of a one-size-fits-all policy and assist the government in tailoring an eventual national program to reflect the diversity of China's regional circumstances. We conclude this article by emphasizing near-term policy steps that will be critical for the long-term development of a national ETS.

First, national legislation authorizing market-based approaches to mitigate climate change should be developed as rapidly as possible. This legislation will need to authorize sufficient penalties for shirking limits on CO_2 emissions and perhaps eventually all greenhouse gases. This would amount to an expansion of the current list of pollutants subject to severe penalties. Without stronger penalties, neither local nor national ETS designs are likely to induce changes in firm behavior. To facilitate efficient operation of a national ETS, legislation also needs to be changed to authorize the operation of carbon exchanges and the large-scale trading of emissions rights.

Second, transparent and independent reporting of carbon emissions is crucial. Yet developing such a system takes time and training of agencies to conduct monitoring, reporting, and verification. The pilot ETS experiences are already generating insights into the gaps and needs of this nationwide data management process. Strengthening this capacity in support of a national ETS will likely take several more years, even with immediate and concerted effort.

Third, and finally, coordination of the many policies—energy, climate, and broader economic (pricing) and fiscal measures that bear on the energy system—will be essential. Creation of an expert assessment team appointed by multiple agencies could help policy makers to identify interactions between an ETS and existing policies, and recommend ways to avoid redundancy. China has

an opportunity to learn from experiences in Australia, California (United States), Canada, Europe, and other parts of the world experimenting with emissions pricing, and relate diversity in policy design across geographies to underlying political, economic, security, and environmental imperatives. Yet when it comes to laying the groundwork for an ETS in China, there is no substitute for continued experimentation and institution building. Given that an ETS broadly supports China's goals of reducing its environmental footprint, upgrading its production structure, and reducing dependence on trade-exposed, energy-intensive industries, a sustained effort to develop an ETS in China is likely to deliver great benefits—nationally and globally—over the long term.

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