SULFURE DIOXIDE EMISSION TRADING IN CHINA: PILOTING PROGRAMS AND ITS PERSPECTIVE

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Abstract: Over the past 10 years, the Chinese State Environmental Protection Administration (SEPA) has actively investigated the potent to use emission trading to reduce sulphur dioxide (SO_2) emissions from electricity generators and industrial sources. In 1999, SEPA partnered with the U.S. Environmental Protection Agency (U.S. EPA) to cooperate on a study to assess the feasibility of implementing SO_2 emission trading in China. SEPA has also pursued emission trading pilot projects in several cities and provinces. The authors, using information from the feasibility study and pilot projects, introduce the circumstances necessary for SO_2 emission trading in China, outline the experience to date, and analyse implementation opportunities and barriers in China. The contents of the paper are: (1) SO_2 emission control policies in China; (2) institutional requirements and the basis for introducing SO_2 emission trading in China; (3) case studies of emission trading in China; (4) opportunities and barriers to implementing emission trading in China; (5) recommendations to transition from pilot projects to a nationwide SO_2 emission trading program; and (6) conclusions and suggestions.
Key words: sulphur dioxide, emission trading, market-based instrument, China

1. BACKGROUND

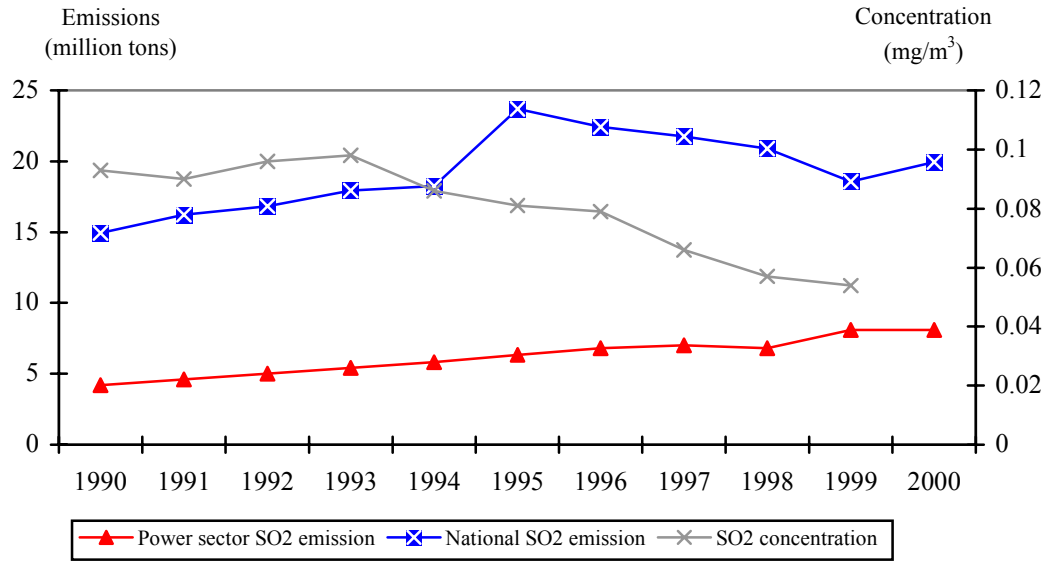
Acid rain and sulphur dioxide (SO2) pollution in China are very severe – ambient concentrations in some regions are several times higher than air quality standards – and have significant impacts on human health, ecosystems, and cultural resources. The toll on human health and the economy from air pollution is estimated to cost as much as 2% of GDP annually (Xie, 1998). As a result, since 1995 the Chinese government has placed great importance on controlling acid rain and SO2 pollution. In order to accomplish this, the government has identified key geographic areas where the problem is particularly severe and adopted a series of policies and measures to abate SO2 emissions. Emission trading is one of the instruments the government is investigating. This paper analyses the opportunities and barriers to implementing SO2 emission trading in China considering current institutional and legal conditions.

1.1 SO_2 Emission Trends

Coal is the principal energy source in China; it's used to meet approximately 69% of China's total primary energy demand (IEA, 2002). Because of a dramatic increase in China's coal consumption over the last two decades due to rapid industrialisation and population growth, SO2 emissions have increased and created serious environmental and human health problems. According to Chinese government statistics, SO2 emissions in China were 19.95 million tonnes in 2000; of which, 85% were from direct coal combustion (Yang et al., 2002). The largest consumer of industrial coal is the Chinese power sector. As a result, the power sector is a major source of SO2 emissions, leading to acid rain and acid deposition across China. These high-stack sources emit 8.9 million tonnes of SO2 annually, 45% of total emissions.

Government data show that total SO2 emissions in China increased between 1980 and 1995 to 23.7 million tonnes. Since a series of SO2 control measures were implemented in 1995, SO2 emissions have declined each year with a small increase in 2000. Figure 1 illustrates the annual SO2 emissions trend in China during the 1990s.

Figure 1: Historic SO_2 Emissions in China



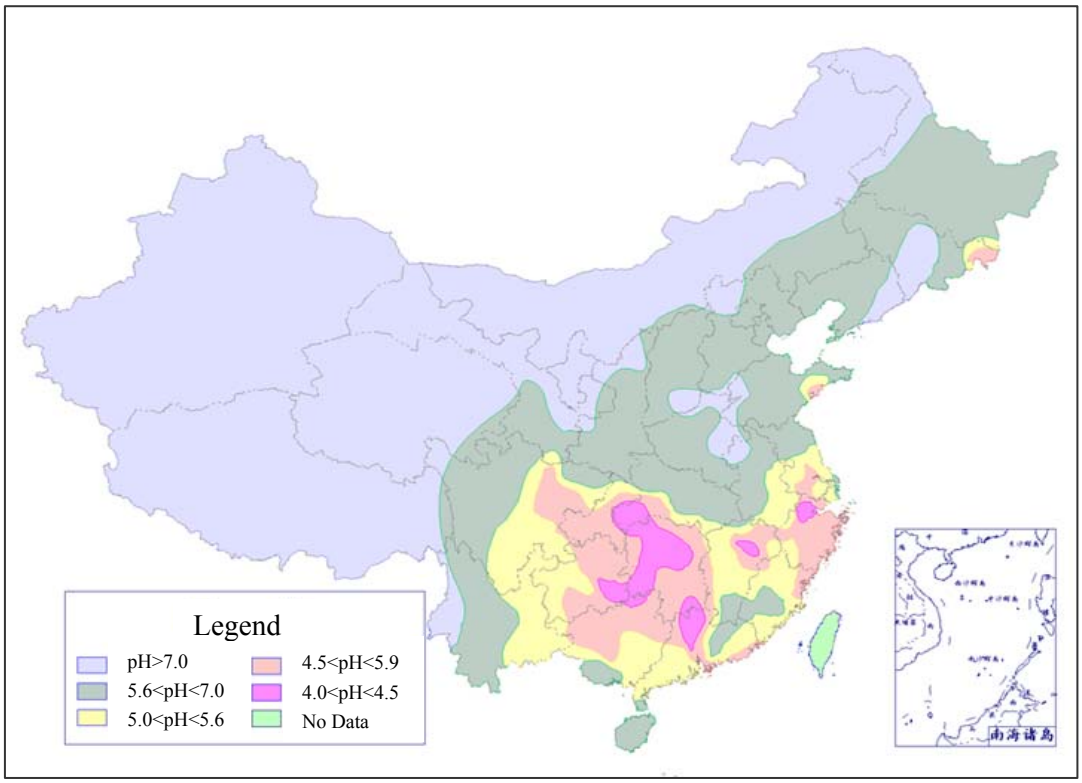
Source: China Environment Yearbook, 1990 to 2001

Emission projections through 2010 show a steady increase in energy demand in China. Much of this demand will continue to be met through coal combustion. By 2010, total annual coal consumption will reach 1.44 billion tonnes and SO2 emissions are estimated to be 26.3 million tonnes (Yang et al., 2002). Therefore, the task of bringing SO2 emissions under control is crucial though challenging.

1.2 Acid Rain and Environmental Impacts

SO2 emissions and the resulting acid rain have serious impacts to human health, visibility, agriculture, forestry, architecture, and cultural resources. From the 1980s to the mid-1990s, the area affected by acid rain increased by more than 1 million km2. Currently, approximately 30% of China experiences precipitation with annual average pH values below 5.6 (Yang et al, 2002). The distribution of areas affected by acid rain is shown in Figure 2.

Figure 2: Distribution of Acid Rain in 1990s



While overall emissions are still high, since 1995 China's total SO2 emissions have decreased. As a result, the number of cities meeting the SO2 concentration standards has increased. But the problem of acid rain has not diminished and the area affected by acid rain and the degree of acidification have not been effectively controlled. Precipitation monitoring data from 530 cities in 2002 showed that 48.9% of the cities suffer from acid rain, 171 cities or 32% have average annual pH values from precipitation below 4.5, and the number of cities with average annual pH values from precipitation below 4.5 is increasing (Qu, 2003). The main reasons are: (1) although total SO2 emissions have decreased, high stack sources contribute an increasing percentage of emissions that are transported over long distances and are acid rain precursors; (2) SO2 emissions from high stack sources in the power sector increased; and (3) there was an increase in emissions of nitrogen oxides (NOx) – another acid rain precursor.

1.3 Identifying Critical Control Zones

Based on areas affected by acid rain and high SO2 concentrations in 1998, the government identified key acid rain control and SO2 pollution control zones known as the "Two Control Zones" (TCZs). The first zone, the Acid Rain Control Zone, consists of areas with average annual pH values for precipitation less than or equal to 4.5, sulphate deposition greater than the critical load, and high SO2 emissions. The second zone, the SO2 Pollution Control Zone, consists of areas with annual average ambient SO2 concentrations exceeding Class II standards, daily average concentrations exceeding Class III standards, and high SO2 emissions. The TCZs are key areas for controlling acid rain and SO2 emissions in China and receive priority for investment and management to control emissions.

1.4 Promoting SO_2 Total Emission Control

In the Ninth Five-Year Plan Period (1996 – 2000), the Chinese State Environmental Protection Administration (SEPA) began to promote a policy of total emission control (TEC). National SO2 TEC targets were established. SEPA then assigned individual TEC targets to provinces, autonomous regions, and municipalities. The regional governments subsequently assigned TEC targets to local governments and/or emission sources.

2. EXISTING FOUNDATIONS FOR INTRODUCING EMISSION TRADING IN CHINA

The U.S. experience has shown that emission trading can be an effective instrument to reduce emissions at lower cost than traditional regulatory policies. For it to be successful, however, several key conditions should be in place. Emission trading works best when: (1) marginal SO2 abatement costs differ among emission sources; (2) the problem is regional or global in scope; (3) emissions can be accurately and consistently measured; (4) there is a strong legal basis for emission trading; and (5) administrative institutions have sufficient capacity to administer the program.

2.1 Variation of Marginal SO2 Abatement Costs

Based on a survey conducted by the Chinese Research Academy of Environmental Sciences (CRAES), there are major differences in marginal SO2 abatement costs among SO2 emission sources. Some of the difference is due to age and type of equipment, access to technologies, technical capacity, location, and fuels. The difference in costs can be as great as 30-50% between regions and 40% between different sectors (Wang et al., 2002). Emission trading has enormous potential to reduce overall costs to industry because of the differences in marginal SO2 abatement costs (low-cost sources could reduce emissions greater than required and sell surplus allowances to high-cost sources, allowing all sources to attain the emission goals and saving money for high-cost sources.)

2.2 Emission Measurement

An effective emission trading program is based on accurate emission measurement and consistent, effective enforcement. Accurate emission measurement from all sources is critical to determine compliance with SO2 TEC policies. For the U.S. emission trading program, the U.S. Environmental Protection Agency (U.S. EPA) requires most emission sources to install continuous emission monitors (CEMs) for SO2 , NOx, and CO2 . The U.S. EPA created a data registry to collect, audit, manage, and disseminate emission data. In China, the introduction of SO2 emission trading will necessitate the establishment and improvement of emission measurement and data management.

Presently, China has mechanisms in place to support SO2 emission measurement. The current emission reporting program stipulates “sources must complete a ‘Form of Emission Reporting’ and provide all necessary data within the time specified by the local Environmental Protection Bureau (EPB).” The emission reporting program forms the basis of the EPBs pollution management. The problem, however, is that most of the SO2 emission data reported by sources are calculated with material balance based on coal consumption and sulphur content of the coal. This approach can be relatively accurate and cost effective when the fuel inputs and production processes are stable. However, when control equipment is installed, material balance does not provide sufficient accuracy for emission trading programs. For a small percentage of enterprises the data are based on monitoring, but only periodic monitoring (e.g., once per quarter or once per year). This, however, is insufficient for emission trading programs because it represents

operating conditions over a very short time period and may not adequately reflect conditions during the rest of the year.

Because SO2 emission sources are numerous – power sector sources and various industrial and heating boilers – it is neither feasible nor necessary to require all sources to install CEMs. Therefore, it is important to classify SO2 emission sources and determine the most appropriate measurement techniques, considering technical, scientific, and economic factors as well as the type and scale of control equipment.

2.3 Legal Basis and Administrative Institutions

Emission trading is a market-based instrument to achieve the TEC limit already established in China. An emission trading program requires significant upfront work to ensure that the program's design is comprehensive and provides the proper incentives for sources to reduce emissions. Designing and operating a program involves setting the TEC target; allocating portions of the target to emission sources in the form of emission allowances; designing trading rules; collecting, verifying, and managing emissions data; managing allowance transactions; and enforcing the program and pursuing punishment for non-compliance. Unless the laws and regulations are clear and complete, the system may be difficult to implement and enforce.

A new amendment to the Air Pollution Prevention and Control Law further clarifies the TEC policy and requires local governments within the TCZs to check and approve total emissions from sources and issue emission permits in accordance with the conditions and procedures the State Council stipulated, taking into consideration the principles of openness, fairness, and justice. The emission permit program explicitly defines emission rights for sources. When one enterprise obtains an emission permit, it receives the authorisation to emit the amount stipulated in the permit. The establishment of emission rights establishes a fundamental condition for emission trading – explicit or de facto property rights.

The current Air Pollution Prevention and Control Law does not contain provisions for a national emission trading program, but future amendments may create such a program.

Regardless of the type of policy instrument, a control program will only be effective if the proper institutions are in place to adequately administer and enforce the program. SEPA is engaged with project partners to enhance the capacity to administer emission trading programs. In addition, pilot projects will help identify deficiencies in local environmental protection bureaus.

3. EMISSION TRADING PILOTS DURING LAST DECADES

Early in the 1980s, China began discussing and piloting emission trading in combination with new projects. The government carried out case studies on the compensated transfer of emission quotas. However, due to legal and regulatory constraints, limited experience, and implementation issues, these experiments were primarily conceptual. In the Ninth Five-Year Plan period, significant progress was made when TEC was promoted nationwide. Interest in emission trading had grown noticeably by the Tenth Five-Year Plan period when TEC became more formal.

Emission trading has transitioned from the concept to pilot stage. SEPA is increasingly attentive of the issue of introducing nationwide emission trading. This transition has occurred over three stages: (1) 1990 to 1995 – establishing the concept; (2) 1996 to 2001 – exploring the theory and methods of emission trading; and (3) 2002 to present – piloting and designing emission trading programs.

3.1 Progress in Piloting Emission Trading in China

In 1994, SEPA conducted policy experiments in air pollutant emission trading in six cities (Baotou, Kaiyuan, Liuzhou, Taiyuan, Pingdingshan and Guiyang) on the basis of air pollutant emission permit pilots in 16 cities.

The pilot trades took many different forms, including:

- Allowance transfers within an enterprise;
- Environmental compensation fees to obtain additional emission rights;
- Investments in non-point source pollution control to obtain additional emission rights; and
- Allowance transfers from sources with surplus allowances to new or existing sources with insufficient allowances.

The trading during these pilots was influenced by political considerations and was not emission trading in the true sense. The pilots were combined with new, expansion, and technical innovation projects arranged by local EPBs. As there was no legal foundation for emission trading, the emission trading policy was implemented through the pollutant permit system that was not adopted nationwide.

In 1999, SEPA and the U.S. EPA began to cooperate on a study to assess the feasibility of introducing SO2 emission trading in China. This study began with significant discussions about the theories, conditions, foundations, and methods of emission trading. The project further explored the opportunities and barriers to implementing SO2 emission trading in the Chinese power sector. Through the cooperation, the countries have conducted several workshops and training activities. As a result, a number of Chinese management and research personnel have a much better understanding of how emission trading works and the conditions necessary for an effective program. The cooperation has promoted emission trading in China.

With financial assistance from the Asian Development Bank (ADB) and technical assistance from Resources for the Future (RFF) – a U.S. think tank – and the Chinese Academy for Environmental Planning (CAEP), Taiyuan city established an SO2 emission trading program in 2001 to attain their SO2 TEC limit at less cost.

In 2002, in order to gain more experience and facilitate nationwide promotion of emission trading, SEPA organized pilots in seven provinces. After one year of preparatory work, some conditions necessary for emission trading were developed. For instance, two power plants in Jiangsu Province reached an agreement to trade SO2 allowances to meet TEC limits.

3.2 Case Studies of Emission Trading

3.2.1 SO_2 Emission Trading in Jiangsu Province

Located in Eastern China, Jiangsu is a province with a relatively advanced economy and effective management institutions. SO2 emissions in the province are significant – 1.2 million tonnes in 2000 – and acid rain has had serious effects on the region. In order to control total SO2 emissions and attain the TEC limit (1 million tonnes) allocated by the central government, Jiangsu introduced an emission trading program to promote cost-effective SO2 abatement in the power sector. The policy framework is outlined in Table 1.

Table 1: The Emission Trading Framework in Jiangsu

Scope:	Power sector – 196 power plants in Jiangsu Province
Region:	The province
Total Emission Target:	TEC limits for the Tenth Five-Year Plan period
Allocation Method:	Emission performance standards
Legal Basis:	Document by provincial EPB and Economic and Trade Commission
Trading Situations:	Two power plants conducted a trade
Monitoring and Measurement:	CEMs, periodic source monitoring, and material balance

Source: Jiangsu Provincial EPB, 2003

Jiangsu focused on the power sector for the pilot study. The sector makes the largest contribution to SO2 emissions in the province. The two power plants that participated in the allowance trade were located in different cities; thereby making the transaction the first inter-city allowance trade in China. Some of the reasons for the program's initial success where: (1) total allowable SO2 emissions from the power sector are controlled by the provincial EPB; (2) allowances were allocated according to uniform standards set by the provincial EPB; and (3) allowances were allocated based on an emission performance standard, or generation performance standard, which is an advanced concept that promotes efficiency.

3.2.2 SO_2 Emission Trading in Taiyuan City

SO2 pollution in Taiyuan is very severe – ambient SO2 concentrations were 0.2 μg/m3 in 2000, three times higher than the Class II standards of 0.06 μg/m3. In an effort to improve urban air quality, the city formulated an ambitious TEC target of 50% below 2000 emissions by 2005. With financial assistance from ADB and technical support from RFF and CAEP, Taiyuan initiated the emission trading project to attain the TEC target at lower cost. After one year of preparation and study, Taiyuan promulgated the "Administrative Regulation for SO2 Emission Trading in Taiyuan City" in 2002 as a local regulation to conduct emission trading. Twenty-three major sources were identified to participate in the first phase of the emission trading program. On the basis of a detailed survey and analysis of SO2 emissions from the sources, allowances were allocated using historic emissions or performance agreements with the city EPB as the basis for the new allocations. The U.S. EPA held training classes for the local EPB and the enterprises participating in the program. In addition, the U.S. EPA helped create SO2 emission and allowance tracking systems. The policy framework for the Taiyuan emission trading program is outlined in Table 2).

Table 2: The Emission Trading Framework in Taiyuan

Scope:	23 key pollution sources accounting for 50% of total SO_2 emissions
Region:	Urban area (excluding suburb districts and counties)
Total Emission Target:	TEC limits for the Tenth Five-Year Plan period –125,000 tonnes
Allocation Method:	Historical emissions
Legal Basis:	Regulation on TEC in Taiyuan City and administrative regulation for SO_2 emission trading in Taiyuan City
Trading Situations:	Training, trading simulation, and implementation beginning January 1, 2003
Monitoring and Measurement:	CEMs, periodic source monitoring, and material balance
Management:	Emission and allowance tracking systems

Source: Cao et al, 2002.

The Administrative Regulation for SO2 Emission Trading in Taiyuan City creates a strong foundation for emission trading and provides detailed implementation requirements. There are seven key aspects of the regulation:

- Identifies Taiyuan city EPB as the supervising institution for SO_2 emission trading.
- Stipulates enterprises participating in the emission trading program are not exempt from other environmental protection responsibilities.
- Specifies the allowance allocations for each year of the Tenth Five-Year Plan period. New sources must obtain allowances through purchases from the city EPB or other sources.
- Allows for the trading and banking of allowances. Surplus allowances from the current year can be banked for use in the future or sold to other sources. If surplus allowances are sold, the trading parties determine the price based on market conditions.
- Authorises an allowance auction by the Taiyuan EPB. Auction income is set aside for improving urban environmental quality.
- Requires the implementation of an emission tracking system and allowance tracking system to manage emission data and allowance transactions.
- Specifies legal liability of enterprises and financial penalties for non-compliance.

4. RECOMMENDATED NATIONAL SO2 EMISSION TRADING PROGRAM

SO2 emission trading has the potential to lower the cost of attaining the TEC targets nationwide. Pilots and research demonstrate that implementing and operating a program within China is feasible. It should, however, be implemented in stages and applied more broadly after pilots are used to test different aspects of the policy. This section outlines some strategies to help nationwide adoption of emission trading.

4.1 National SO_2 TEC Targets

Emission trading is compatible with the national TEC targets. To ensure that the policies complement one another, the design of the emission trading policy should be integrated with the national TEC limit so as to facilitate the attainment of the TEC target.

SEPA has already established the national SO2 TEC target for the Tenth Five-Year Plan period. The target limits SO2 emissions in 2005 to 10% below 2000 emissions and 20% below 2000 emissions in the TCZs. Detailed TEC targets are presented in Table 3.

Table 3: SO_2 TEC Targets in 2005

Regions	*2000 (1,000 tonnes)*	*2005 (1,000 tonnes)*
China	19,950	17,950
TCZs	13,164	10,536
SO_2 Control Zones	5,296	4,234
Acid Rain Control Zones	7,868	6,302

Source: State Council, 2001

4.1.1 The Power Sector SO_2 TEC Target

According to a CAEP research report on long- and medium-term emission control plans in power sector, the TEC target for the power sector over the next 20 years will continue to decline (Yang et al., 2002). See Table 4 for the power sector TEC targets.

Table 4: SO_2 TEC Targets in the Power Sector – 2000 to 2020

Year	*TEC Target (1,000 tonnes)*
2000 (base year)	8,900
2005	8,000
2010	7,300
2015	6,700
2020	6,300

Source: Yang et al., 2002

4.2. Implementing the TEC

The circumstances for SO2 emission trading policies in China and the U.S. differ significantly, including:

- The composition, distribution, and contributions of the emission sources;
- The structure and role of central management institutions;
- Ownership – private versus state owned;
- Experience with markets for commodities like electricity;
- Access to capital and control equipment; and
- Existing policies and measures.

SO2 emission sources in China are primarily classified as industrial or social. Alternatively, the sources can be classified into regions, such as acid rain zone, SO2 control zone, and general zone. They can also be classified by emission source, such as high stack sources, low stack sources, and non-point sources. High

stack sources are found mostly in the power sector. There are a limited number of sources, they are often controlled centrally, and they are easier to manage. The low stack sources are various types of boilers and furnaces. They are numerous, widely distributed, and difficult to manage. The non-point sources are primarily diffuse residential stoves.

4.2.1 Power Sector

Promoting SO2 emission trading in the power sector provides many advantages. The sector accounts for 45% of national SO2 emissions, sources primarily use high stacks, and, as a result, are key contributors to the regional acid rain problem. Decreases in their emissions should significantly improve regional pollution problems. Other important conditions for emission trading exist in the power sector, such as strong management, good emission data, and a relatively high economic efficiency.

There are still, however, some key barriers to implementing emission trading in the power sector, such as:

- *Ownership:* The enterprises in the power sector are mainly state owned and currently undergoing restructuring. The progress of restructuring will directly affect the implementation of SO_2 emission trading policy.
- *Electricity pricing*: The price of electricity is an important factor limiting SO_2 abatement in the power sector. The government fixes prices and the sector cannot pass environmental costs to ratepayers. If the electricity pricing policy is not adjusted, sources of funding will be limited and it will be difficult for the sector to adopt effective abatement measures. However, the government is currently reforming national electricity price policy.
- *TEC limit allocation:* The allocation of TEC limits is a two-stage process. First, portions of the national target are allocated to the power sector. Second, portions of the power sector target is allocated to individual sources. There is currently no standard allocation methodology for sources. In addition, allocations are often for short periods (e.g., five-year plan periods) and may not provide enough information for sources to develop investment plans.
- *Emission measurement:* Most enterprises in the power sector, except some 10 to 19 new plants, do not have CEMs. Even in those new plants, CEMs often fail to operate normally. In order to promote SO_2 emission trading, it is important to establish standards for certification, installation, maintenance, and calibration of CEMs.
- *Data management systems:* It is critical to establish management systems to collect, verify, manage, and disseminate emission data. It is also important to develop data standards for reporting.

4.2.2 Two Control Zones

Sixty percent of national SO2 emissions occur in the TCZs. Since the TCZs are identified as areas of national focus for controlling SO2 and acid rain, the promotion of SO2 emission trading in the TCZs can be a part of national SO2 control strategy. There are abatement targets and emission caps already defined for the TCZs. Therefore, it is practical to conduct SO2 emission trading pilots in the TCZs. In these pilots the following issues should be considered:

There are several types of sources in the TCZs and it is impossible to implement emission trading for all source types. It is therefore necessary to classify sources in the TCZs and select the key ones for an emission trading pilot before broadening the scope.

In the TCZs it is necessary to distinguish between high stack sources and low stack sources. The former have regional pollution impacts and can therefore trade in a larger area while the latter have primarily local impacts and should therefore only trade with other local sources.

4.3 Implementation Phases

The feasibility study on SO2 emission trading in China prepared by CAEP, U.S. EPA, and experts recommends implementing SO2 emission trading at the national level in four stages (WANG et al. 2003):

- *Phase One:* a pilot phase with trading limited to large power plants (i.e., annual SO_2 emissions greater than 5,000 tonnes) in the TCZs;
- *Phase Two:* an expanded pilot with trading between all power plants in the TCZs on the basis of phase I;
- *Phase Three:* a nationwide program including all power plants in China; and
- *Phase Four:* an expanded nationwide program including other types of high stack sources.

A pilot restricted to sources in the TCZs is consistent with China's current SO2 management framework. Limiting the pilot to power plants focuses SO2 control in China and facilitates management of emission trading. From the standpoint of the power sector, it is feasible to establish a national SO2 emission trading program as it may help balance the cost differences in pollution abatement among different sources.

4.4 Feasibility of National Implementation

Although current conditions are far from perfect for an efficient emission trading program, they create the foundation for pilot emission trading programs that can help further develop necessary conditions and institutions. Prevailing conditions include:

- Wide acceptance of the emission trading concept. The role of emission trading in decreasing costs to achieve an environmental goal is well understood.
- Implementation of SO_2 TEC limits. The TEC limits establish the environmental goal, emission trading and market-based instruments provide the means to achieve the goal at a lower cost.
- Experimentation with emission trading pilots. Pilots in some provinces and cities have provided valuable experience and forged the path to expand emission trading nationwide.
- Outreach and capacity building for emission trading. SEPA has organized a series of studies and has developed technical capacity on the design of emission trading programs.

5. CONCLUSIONS AND SUGGESTIONS

In summary, the following conclusions and suggestions are provided:

- SO_2 TEC in China should be combined with a national emission trading policy to help attain the control target at lower social cost.
- After nearly 10 years of analysis and emission trading pilots, several cities and regions have practical experience that provide the necessary foundation for introducing emission trading nationwide.
- There are issues and barriers to overcome before implementing a nationwide emission trading program, including legal authority, policy coordination, allocation issues, emission measurement and verification, and supervision and management systems.

In order to support national implementation of emission trading, some basic conditions should be improved, including:

- Establish an explicit legal basis for emission trading. SEPA should draft emission trading provisions that are integrated with the TEC regulation.
- Strengthen measurement and verification of SO_2 emissions to improve accuracy. Major stationary sources of SO_2 should install CEMs. Those sources without CEMs should be encouraged to apply more accurate emission measurement methods. SEPA should draft standards and/or guidelines for CEM certification, installation, maintenance, calibration, and verification to ensure accurate emission measurement. SEPA should also develop procedures for measuring and verifying emissions from sources without CEMs.
- Design an equitable allocation method that provides proper incentives for sources to take action to reduce SO_2 emissions.
- Implement management systems to collect, verify, manage, and disseminate emission and allowance data. The management systems should complement existing systems in place for the TEC policy.
- Strengthen education and outreach on emission trading.
- Implement emission trading in phases with high-emitting, high stack sources in the TCZs participating in the first phase and a gradual expansion as capacity increases.

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