Shanxi Air Quality Improvement Project

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IN COOPERATION WITH

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RESOURCES FOR THE FUTURE

Shanxi Air Quality Improvement Project

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EXECUTIVE SUMMARY

As part of a loan for air quality improvement in Shanxi Province in the People's Republic of China (PRC), the Asian Development Bank (ADB), in cooperation with the Shanxi Planning Commission, initiated a technical assistance grant (TA) in March 2001 to enhance the use of market-based instruments for air quality management in Shanxi. The provincial capital city of Taiyuan was selected as the site for a demonstration of the use of market-based instruments for sulfur dioxide (SO_2) control—specifically a cap-and-trade program involving large point sources.

Resources for the Future (RFF), a Washington, D.C.–based research institution, was selected to lead this TA, in cooperation with Resource Consulting Associates, Inc., the Norwegian Institute for Air Research (NILU), and the Chinese Research Academy for Environmental Science (CRAES). In addition, the U.S. Environmental Protection Agency (EPA) provided extensive assistance in the areas of training and capacity building.

Over the course of this TA, the RFF team made more than a dozen site visits to the province, collected and analyzed data, prepared key documents, developed new computer-assisted management tools, and conducted numerous training sessions as part of a demonstration of emissions trading in Taiyuan.

As this TA comes to an end, the components of the cap-and-trade system are in place. To arrive at this point, a number of specific milestones were achieved:

- education of government and industry leaders about the benefits of adopting emissions trading in Shanxi Province and Taiyuan City;
- establishment of facility-specific emissions caps for large emissions sources for the years 2002–05;
- promulgation by Taiyuan City in October 2002 of a formal regulation on emissions trading and the administrative framework to support the regulation;
- development and demonstration of various computer-based tools designed to facilitate emissions monitoring and verification (the emissions tracking system) and management of the allowances (the allowance tracking system);
- capacity building and training on the theory, practice, and management of emissions trading systems, for both government and industry, including senior officials as well as technical and managerial staff; and
- initial simulation of emissions trading among selected facilities (two large power plants, a small power plant, and a heavy machinery manufacturer).

Overall, the RFF team believes that this TA has succeeded in laying the foundation for effective and efficient SO_2 control in Taiyuan and advancing the emissions trading model to a point that other areas of Shanxi Province can adopt it. Whether or when this system becomes fully operational remains to be seen. Continued support by both domestic and international experts to facilitate the initial operation and help ease the "growing pains" of the system is recommended, as is a further evaluation of the system when it reaches full-scale operation. Sixteen specific recommendations to advance the use of emissions trading in Taiyuan and elsewhere in Shanxi Province are presented below.

Background

The PRC has serious air pollution problems largely because of its heavy reliance on coal combustion as a major source of power and the limited treatment of emissions. Particulate matter (PM) and SO_2 are of particular importance because inhalable particulate matter has been closely linked to mortality effects; SO_2 is of concern largely because of atmospheric conversion to sulfates, a fine particulate. In response, the PRC has sought to develop effective and efficient policies to reduce PM and SO_2 concentrations, both in the power sector nationally and in regions with poor air quality.

Taiyuan, with a population of 2.7 million, is located 500 kilometers southwest of Beijing. The mountains that surround the city on three sides create a natural smog trap in which air pollutants tend to accumulate. The annual daily SO_2 concentrations in Taiyuan averaged 0.2mg/m^3 in 2000, much higher than the PRC's Class II annual standard (0.06mg/m^3).

The Taiyuan City government had proposed a more than 50% reduction in SO_2 emissions as part of its five-year environmental plan ending in 2005. Market-based instruments, such as emissions trading, have the potential to facilitate achievement of this very ambitious goal at a lower cost than alternative approaches.

Emissions Trading

Among developing countries, the PRC has been a pioneer in the use of certain economic instruments, notably the pollution levy system. Although the pollution levy system serves as an integral component of environmental management in the PRC, its principal aim is to fund regional and local environmental protection bureaus (EPBs) and help finance pollution control measures. However, despite recent increases in the levy rates and other reforms of the system in 2000 and 2002, the rates are still too low to create adequate incentives to meet the pollution reduction goals of the Tenth Five-Year Plan.

In the early 1990s the PRC began to require emissions offsets at selected new facilities. These pilot projects revealed that emissions trading was feasible, at least in this primitive form. Taiyuan agreed with ADB to participate in a demonstration of emissions trading patterned after the highly successful U.S. experience using emissions trading for acid rain control. The particular form of emissions trading developed for Taiyuan is known as a cap-and-trade system. In contrast to pollution levies, which if set at sufficiently high levels rely on price signals to induce reductions in emissions, a trading system sets emissions quantity targets, distributes permits to the emitting firms, and allows the trading of the permits among the firms in the system.

By reducing SO_2 emissions, the U.S. Acid Rain Program is providing health and environmental benefits estimated to be many times greater than costs. Based on evaluation methods similar to those used in the United States, the RFF team estimated that benefits to Taiyuan from the proposed 50% reduction in citywide SO_2 emissions likewise would exceed control costs. Conservative calculations indicate that attainment of the Class II standards could avert 402 to 1,886 deaths annually in Taiyuan.

Researchers have documented cost savings from the use of emissions trading to manage acid rain in the United States at 40% or more compared with conventional approaches. The principal reason for these savings is the relatively large difference in marginal abatement costs among pollution sources. The RFF team documented similar differences in marginal abatement costs among sources in Taiyuan.

Emissions trading encourages sources with higher unit control costs to reduce each unit of emissions to pay the sources with lower unit control costs to clean up more than is required by regulation. This trade-off has important efficiency and distribution implications. It provides benefits to society because low-cost sources carry out emissions reductions beyond what is required by regulation. High-cost sources benefit because they can pay the low-cost sources less than it would cost to make the reductions on their own. Low-cost sources benefit by receiving compensation from high-cost sources for their excess reductions. The result is attainment of the overall emissions goal at a lower cost to society. Emissions trading also creates flexibility in the timing of compliance, smoothing out pollution control investment needs through emissions banking, a form of intertemporal trading. For all these reasons, emissions trading has the potential to be an attractive instrument for environmental management, particularly in a country that, like the PRC, contemplates making major new pollution control investments in the coming years.

The challenge is to apply these techniques in a nation where legal and institutional arrangements for environmental management are still in their formative stages. Although the PRC is a rapidly evolving market economy, it has little experience with rigorous environmental monitoring and enforcement or with trading of intangible commodities like pollution credits. Steady, reliable, fair enforcement and a well-constructed program to detect and act on violations are basic building blocks of any environmental management system, whether that system uses conventional tools or market-based instruments. This TA has accorded high priority to identifying gaps in all areas of the environmental management system and helping to fill those gaps. For example, training was provided on various aspects of monitoring, reporting, and enforcement. Further, a user-friendly emissions allowance tracking system was developed expressly for the purpose of overcoming some of the perceived deficiencies in monitoring and reporting.

Major Accomplishments

The adage that "Rome wasn't built in a day" aptly describes the difficulties involved in introducing a rigorous new environmental management system in Taiyuan. Establishing a program of emissions trading is somewhat like building a complex mosaic. A large number of intricate elements must be fit together. These range from technical components, like air quality monitoring, to policy-relevant and sometimes politically sensitive issues, such as designing a viable sys-

tem and establishing an appropriate legal framework. The exercise is not merely a matter of mechanically assembling pieces into a working whole. Various stakeholders and constituents must learn how such a program might work, agree it is in their interests to be part of the effort, and be trained to do their share in making it a reality. Thus, an important part of the demonstration in Shanxi Province includes capacity building for and with the people, institutions, and myriad potential participants in the trading program, to develop fluency with and support for the principles involved.

In preparation for the time when a full-scale emissions trading system would become functional in Taiyuan, this TA has achieved a number of major milestones, including the following accomplishments:

- ***Education of government and industry leaders about the benefits of adopting emissions trading in Shanxi Province and Taiyuan City***

One of the most important accomplishments of this demonstration project was thast during the course of this project senior officials at the provincial and local levels of government realized the importance of emissions trading. Although it is difficult to summarize the results of these discussions in a simple way, it is fair to say that the senior leaders in government and industry in Shanxi Province gained an understanding and appreciation of how emissions trading could be used to advance the goals of environmental management in the province, particularly in Taiyuan.

- ***Promulgation of a formal regulation on emissions trading and establishment of an administrative framework to support the regulation***

A. Administrative regulation on SO_2 emissions trading program in Taiyuan. In October 2002, the Taiyuan City government promulgated a regulation for the emissions trading program, based on a draft proposed by the RFF team. The regulation contains several key provisions that create the legal basis for the program. Although some controversial issues remain, such as the cap on penalties, the Taiyuan regulation is notable as the first comprehensive regulation of its kind in China to support emissions trading on a citywide basis.

B. Allocation of allowances. In December 2002, the Taiyuan Environmental Protection Bureau (TEPB) issued the future allowance allocations for each of the enterprises based on an initial analysis prepared by the RFF team. The allocations were based on historical emissions data with a goal of reducing overall emissions by 50% relative to year 2000 emissions. Enterprises for which a specific emissions reduction goal had been set in the city's Tenth Five-Year Plan received the allocation stipulated in the plan.

C. Administrative framework to support the regulation. In 2002, to facilitate the implementation of the regulation, the RFF team helped develop a procedural guidance document. This document lays out the functions and responsibilities of both the government and the enterprises, lists all the procedures that the government and enterprises need to follow in the process of emissions trading, and develops the documentation necessary for the administration of the program.

■ ***System development***

Another accomplishment of the Taiyuan project is the development of two computer-based analyses to facilitate actual implementation: the emissions tracking system and the allowance tracking system. These are the first such systems to be used in an emissions trading program in China.

A. Emissions tracking system (ETS). The emissions trading regulation calls for an emissions tracking system to manage emissions reports from enterprises and the TEPB monitoring bureau. The ETS collects data on fuel inventories and fuel consumption as a basis for calculating total emissions during the compliance period. In addition to calculating emissions from mass balance formulas, the ETS collects data from the monitoring bureau to facilitate comparison of each enterprise's emissions measurements. Data about production levels are also collected to establish emissions rates (for example, emissions per unit of output) that TEPB can use to identify possible discrepancies in an enterprise's submission.

B. Allowance tracking system (ATS). The emissions trading regulation includes a provision that requires TEPB to establish an allowance tracking system to manage allowance allocations and transfers. The ATS is a software application developed by the RFF team that was installed at TEPB in December 2002. The application facilitates allowance accounting, including the creation of allowance accounts, issuance and allocation of allowances to the enterprises, transfer of allowances among enterprise accounts, and allowance deductions to offset emissions during the compliance year. In addition, the data and reports from the ATS can be used to publicize the results of the trading program.

■ ***Capacity building and training***

In cooperation with the U.S. Environmental Protection Agency, seven major training sessions were conducted on the basics of emissions trading, design elements of emissions trading programs, the importance of accurate emissions measurement, the role of computerized tracking systems to manage emissions and allowance data, enforcement needs, and participation in the Taiyuan emissions trading program.

■ ***Publicity and public involvement***

The Taiyuan project is part of a broader effort by the State Environmental Protection Administration (SEPA) to promote emissions trading nationwide in China. The Taiyuan demonstration has gained considerable prominence and has been reported on by various media in China. The Taiyuan project has also been written up in several international publications, including *The Economist* magazine.

- ***Initial simulation of emissions trading among selected facilities***

In December 2002, the RFF team helped test the procedures and systems for emissions trading. Four enterprises were selected to participate in the simulation. A hypothetical compliance year was established and procedures were tested for account creation, allowance allocation, emissions reporting and verification, allowance trading, auction operation, and compliance determination. The test trades helped give both TEPB and the enterprises further insights about how the overall system works, how trading would occur, what steps to follow in conducting trades, and what role allowance prices play in helping guide investment decisions for pollution control abatement.

Recommendations

The report makes 16 specific recommendations designed to advance the use of emissions trading in Taiyuan and elsewhere in Shanxi Province. There are three kinds of recommendations: technical adjustments, institutional strengthening, and improved coordination and information flow. Table ES-1 summarizes the followup activities.

- ***Technical adjustments to the emissions trading plan***

A. Increase compliance incentives by lifting the cap on total penalties. Article 23 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City sets a yearly cap of 30,000 yuan on the total penalties that can be assessed against polluters. The obvious difficulty with this provision is that if the cost of compliance (whether installing technology, making process changes, or purchasing allowances) is greater than the maximum stipulated by the penalty cap, the incentives for enterprises to come into compliance are dramatically reduced, since the cap limits their overall penalty payments.

Recommendation: Specific actions should be initiated in the near term to develop a formal request to the Provincial People's Congress to lift the penalty cap.

B. Clarify allocation policy for modification, expansion, and other changes at firms. Article 11 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City stipulates that: "Modification, expansion, amalgamation, and separation of existing polluting sources will not increase SO_2 allowances. A new enterprise in the trading program can acquire allowances from other enterprises, or get allowances in the allocation of the next Five-Year Plan." This provision creates a potential barrier to mergers and consolidations that may be beneficial to the local economy, and it does not appear to be necessary for success of the emissions trading program.

Recommendation: It is recommended that decisions on mergers involving firms that do not participate in the trading program be decided on a case-by-case basis.

C. Allow allowance use after shutdowns and conversion to central heating. Article 10 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City states that: "In case of reductions in SO_2 emissions because of conversion to central heating, plant shutdown, merger, relocation and bankruptcy of enterprise, etc., city environmental protection department shall take back or adjust the emissions allowance of the polluters." Since it is not clear what the gov-

TABLE ES.1

Recommended Followup Activities

Recommendation	Remarks	ADB Support Required?
Technical Adjustments		
Increase compliance incentives by lifting the cap on total penalties.	Taiyuan and Shanxi governments should initiate specific action in the near term to develop a formal request to the People's Congress to lift the penalty cap.	Possible: government-lead activity, but external advice on calculating penalties may be warranted.
Clarify allocation policy for modification, expansion, and other changes at firms.	Decisions on mergers involving firms that do not participate in the trading program should be decided on a case-by-case basis.	No: government-lead activity.
Permit allowance use after shutdowns and conversion to central heating.	The broad-scale requirement that allowances be returned to TEPB after shutdowns and conversion to central heating should be removed from the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City and further clarification should be provided.	Possible: government-lead activity, but external advice on alternatives for banking such allowances may be warranted.
Allow banking.	This provision should be modified to allow banking of surplus allowances without prior approval by TEPB.	Possible: external advice on banking may be warranted.
Institutional Strengthening		
Improve emissions measurement.	TEPB should focus additional management and technical resources on the issues of emissions measurement and management of the emissions data. Without accurate and timely measurement of emissions, it will not be possible to achieve major emissions reductions in Taiyuan via emissions trading or any other approach.	Possible: government has informally requested that surplus funds from Loan 1715-PRC used for purchasing monitoring equipment.
Augment financing for emissions controls.	The provincial and national governments, possibly in coordination with international financial institutions like ADB, should consider providing additional financing assistance for pollution control equipment, especially to enterprises participating in emissions trading programs.	Possible: ADB or other international financial institution support to enterprises is constrained by Ministry of Finance policy (No. 1, January 2000).
Improve enforcement.	TEPB should broaden the set of enforcement tools used to encourage compliance by strengthening the existing permit system, for example.	Possible: further dialogue with government needed to determine appropriate scope of ADB support.
Establish realistic but firm emissions reduction targets in national and province-level five-year plans.	The goal-setting process should be reformed to more explicitly account for economic, technical, and financial feasibility and to incorporate explicit consultation with industry in advance of establishing the formal goals. This recommendation applies to goal setting at all three government levels—national, provincial, and local.	Possible: further dialogue with government needed.

Recommendation	Remarks	ADB Support Required?
Establish realistic but firm emissions reduction targets for sources in Taiyuan.	TEPB should evaluate progress to date and developa realistic timetable for firms to come into a full compliance. If the original target is still valid, that point should be clearly made to the enterprises. If some leeway in meeting the target is anticipated, that should also be clearly articulated. In general, uncertainty about binding regulatory requirements is not conducive to environmental progress.	Possible: further dialogue with government needed.
Conduct additional training.	Conduct additional training on program operation, emissions measurement, and measurement and control technologies.	Possible use surplus funds from Loan 1715-PRC.
Continue research and analysis as the system moves into full-scale operation.	Continue research and analysis as the emissions trading system becomes fully operational. Be prepared to revise the system as needed.	Possible: external advice may be appropriate.
Improving Coordination and Information Flow		
Improve policy coordination among different levels of government.	The emissions trading demonstrations should be more closely coordinated within Shanxi Province and among the various levels of government. Specifically, plans to develop a province-wide emissions trading program in the electric power sector should be integrated with the Taiyuan emissions trading demonstration.	Possible: further dialogue with government needed to determine appropriate scope of ADB support.
Establish a mediation committee.	Establish a mediation committee or similar process for resolution of possible disputes that can arise in the context of an emissions trading program.	No: government-lead activity.
Make information about emissions trading programs publicly available.	Since TEPB has already proposed creating a Web page, it is recommended that this Web page be used to provide participating enterprises and the general public with information about the details of the program, including emissions, allowance trades, and compliance, in a format that will increase understanding of emissions trading and minimize suspicion that might taint the program.	Possible: use surplus funds from Loan 1715-PRC.
Establish an advisory group to assess Taiyuan's emissions trading demonstration.	Establish a high-level advisory group to assess the Taiyuan demonstration and a working group of technical staff to monitor the detailed operation of the demonstration.	No: government-lead activity.
Analyze the incentives for trading and publicize the benefits to enterprises.	Particularly as the emissions trading program begins operation, TEPB should continue to analyze the incentives for emissions trading and should publicize the results of trades, both within the regulated community and beyond.	Possible: external advice may be appropriate.

ernment would do to reallocate the allowances revoked in the specified circumstances, this provision would seem to create additional uncertainties for firms without adding any significant environmental benefits.

Recommendation: The broad-scale requirement that allowances be returned to TEPB after shutdowns and conversion to central heating should be removed from the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City, and further clarification should be provided.

D. Allow banking. The emissions trading regulation specifies that enterprises must seek approval from TEPB before using banked allowances to cover emissions during the compliance period. However, because an enterprise will not know the outcome of an application until after the compliance year is over, there is no opportunity to further reduce emissions or purchase allowances from other enterprises if the request is denied. Therefore, this provision effectively prevents banking of excess allowances. Limiting the use of the banking provision in this manner will raise the costs of meeting the caps without generating any significant environmental benefits. Concern that the banking provision may allow emissions to increase beyond acceptable levels does not seem warranted.

Recommendation: This provision should be modified to allow banking of surplus allowances without prior approval by TEPB.

- ***Institutional Strengthening***

A. Improve emissions measurement. A cornerstone of any successful emissions trading program is the accurate quantification of emissions. If emissions cannot be accurately measured, they cannot be managed. Ideally, this is done with continuous emissions monitoring devices. However, alternative protocols can also be used as long as specific procedures are instituted to ensure their integrity. Currently, TEPB employs a technique for measuring emissions that is sound in principle but potentially inaccurate in at least two respects. It relies on firms to report hours of operation, and it assumes that emissions measured during the sampling visits are representative of emissions at other times.

Recommendation: TEPB should focus additional management and technical resources on emissions measurement and management of the emissions data. Without accurate and timely measurement of emissions, it will not be possible to achieve major emissions reductions in Taiyuan via emissions trading or any other approach.

B. Augment financing for emissions controls. Although emissions trading can potentially reduce both the immediate and the longer-run financial burden on firms with responsibilities to cut emissions, it will not reduce these burdens altogether. Based on the U.S. experience, emissions trading reduces compliance costs by one-third or more, yet substantial emissions control investments are still required. Based on interviews conducted in Taiyuan, it appears that firms are facing difficulties in financing required pollution controls.

Recommendation: The provincial and national governments, possibly in coordination with international financial institutions like ADB, should consider providing additional financing assis-

tance for pollution control equipment, especially to enterprises participating in emissions trading programs.

C. Improve enforcement. One of the significant issues facing Taiyuan environmental officials is how to ensure that enterprises are following the rules and that real reductions in emissions are being achieved. As they seek to accomplish this, the Taiyuan enforcement officials face several challenges. For example, they have only a limited number of enforcement tools.

Recommendation: TEPB should broaden the set of enforcement tools used to encourage compliance. For example, it is recommended that unannounced inspections be increased, missing data procedures be established, a clear chain of command for taking enforcement action be developed, and a penalty structure be set up that explicitly accounts for *de minimis* as well as large violations.

D. Establish realistic but firm emissions reduction targets in national and provincial five-year plans. Emissions targets established in the five-year plans do not appear to have been set with any explicit consultation with industry about what it considers feasible and what technologies are available (particularly in the local market), at what cost and with what type of financial assistance. As a result, there are serious questions about the credibility of the national and provincial targets.

Recommendation: The goal-setting process should be reformed to more explicitly account for economic, technical, and financial feasibility and to incorporate explicit consultation with industry in advance of establishing the formal goals. This recommendation applies to goal setting at all three government levels—national, provincial, and local.

E. Establish realistic but firm emissions reduction targets for sources in Taiyuan. More than two years of the five-year plan have passed in which SO_2 emissions were to be reduced by more than 50%. To date there has been only limited progress in reducing total emissions.

Recommendation: TEPB should evaluate progress to date and develop a realistic timetable for firms to come into full compliance. If the original target is still valid, that point should be clearly made to the enterprises. If some leeway in meeting the target is anticipated, that should also be clearly articulated. In general, uncertainty about binding regulatory requirements is not conducive to environmental progress.

F. Conduct additional training. Education is the key to developing an understanding of the complexities involved with designing and operating a regulatory program. The RFF team has conducted seven major training sessions for TEPB and enterprise managers. To date, training has focused on program design and requirements. As actual implementation proceeds, additional training will be necessary to expand, update, and reinforce current knowledge about the environmental management system.

Recommendation: Conduct additional training on program operation, emissions measurement, and measurement and control technologies. Domestic funds could support such activities, and funds from ADB Loan 1715-prc could also be used.

G. Continue research and analysis as the system moves into full-scale operation. International experience with emissions trading and other environmental management systems suggests that new issues tend to be identified once the system becomes fully operational. For example, one issue that has recently arisen in model simulations is the potential for emissions trading to have (somewhat) disproportionate air quality impacts in different zones in Taiyuan, depending on the nature (and direction) of the trades. As the system becomes fully operational it would be appropriate to examine this issue further, with the possibility of revising the trading rules, if warranted.

Recommendation: Continue research and analysis as the emissions trading system becomes fully operational. Be prepared to revise the system as needed.

- ***Improving coordination and information flow***

A. Improve policy coordination among different levels of government. Currently, there appears to be only limited coordination among national, provincial, and local governments concerning innovative policies like emissions trading. In Shanxi Province, for example, active discussions are under way concerning the establishment of a province-wide emissions trading program focused on power plants.

Recommendation: The emissions trading demonstrations should be more closely coordinated within Shanxi Province and among the various levels of government. Specifically, plans to develop a province-wide emissions trading program in the electric power sector should be integrated with the Taiyuan emissions trading demonstration.

B. Establish a mediation committee. Disputes between industry and regulators or among trading partners can be expected in emissions trading (and most other) systems. Whether the disputes arise from simple misunderstandings or from complex legal or strategic issues, there is a need to establish some mechanism to provide a forum for resolution of possible disputes. One option would be to establish a mediation committee to carry out that function.

Recommendation: Establish a mediation committee or similar process for resolution of possible disputes that can arise in the context of an emissions trading program.

C. Make information about emissions trading programs publicly available. U.S. experience with SO_2 trading in the acid rain program demonstrates that full and open disclosure helps prevent cheating and corruption of the program and thereby builds public confidence. A similar campaign to inform the public in the PRC may reduce suspicions that the program has been instituted to benefit favored units and also increase support and understanding of the goals of emissions trading.

Recommendation: Since TEPB has already proposed creating a Web page, it is recommended that this Web page be used to provide participating enterprises and the general public with information about the details of program, including emissions, allowance trades, and compliance, in a format that will increase understanding of emissions trading and minimize suspicion that might taint the program.

D. Establish an advisory group to assess Taiyuan's emissions trading demonstration. Discussions in the course of the project highlighted the need for clear and unequivocal demonstrations of support by high-level Taiyuan City and Shanxi Province government officials. Firms are more likely to support the trading program when they understand that the government is serious about reducing emissions and that it stands behind a program to reduce emissions in the most efficient manner.

Recommendation: Establish a high-level advisory group to assess the Taiyuan demonstration and a working group of technical staff to monitor the detailed operation of the demonstration.

E. Analyze the incentives for trading and publicize the benefits to enterprises. Variation in the overall cost-effectiveness of emissions control creates the opportunity for achieving emissions reductions through trading, since enterprises will seek the most cost-effective means of complying. The incentives to participate in trading are closely related to the mandatory nature of compliance and the risks of noncompliance, however. If enterprises discover that compliance is negotiable, the main incentive for trading—the opportunity for cost savings against real expenditures toward compliance—is diminished.

Recommendation : Particularly as the emissions trading program begins operation, TEPB should continue to analyze the incentives for emissions trading and should publicize the results of trades, both within the regulated community and beyond.

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CHAPTER ONE

Introduction

The People's Republic of China (PRC) has serious air pollution problems, largely as a result of its heavy reliance on coal combustion as a major source of power and limited treatment of air pollution. Sulfur dioxide (SO_2) is of particular importance because it has been closely linked to mortality effects, primarily through conversion to sulfates, a fine particulate. In response, the PRC is seeking to develop effective and efficient policies to reduce SO_2 concentrations in the power sector nationally and in regions with poor air quality. Areas like Shanxi Province, where some of the highest SO_2 levels in the nation—and the world—are now recorded, are targets for such regional attention.

Accordingly, the Asian Development Bank (ADB), in cooperation with the Shanxi Planning Commission, initiated a technical assistance grant (TA) to enhance the use of market-based instruments for air quality management in Shanxi and to strengthen the institutional capabilities of the provincial agencies to facilitate implementation of such instruments. A demonstration program in the provincial capital city of Taiyuan was envisioned as a key step toward enhancing the use of market-based instruments for SO_2 control.

Studies by the Asian Development Bank and others of the potential application of market-based instruments to enhance air quality in the People's Republic of China, including some limited pilot projects, have been under way for more than a decade. This project brings these efforts a great deal closer to the goal of full-scale implementation.

Resources for the Future (RFF), a Washington, D.C.–based research institution, was selected to lead this TA, in cooperation with Resource Consulting Associates, Inc., the Norwegian Institute for Air Research (NILU), and the Chinese Research Academy for Environmental Science (CRAES).[1] In addition, the U.S. Environmental Protection Agency (EPA) provided extensive assistance in the areas of training and capacity building.

Over the course of this TA, which was initiated in March 2001, the RFF team made more than a dozen site visits to the province and conducted numerous training sessions and other activities designed to develop and demonstrate the viability of emissions trading in Taiyuan (see Appendix 1 for a summary of field trips). This document reports on the results of this demonstration project.

Why Emissions Trading?

The PRC faces most of the traditional dilemmas of the developing world that create a compelling rationale for economic and administrative efficiency in improving environmental quality. It is

certainly not a country that can afford wasted effort in confronting its significant environmental health problems. For this reason, the PRC needs well-designed policies and institutional mechanisms to address the challenges posed by high SO_2 concentrations.

In fact, the PRC has been a pioneer in developing a framework for economic incentives, in the form of the pollution levy system. Piloted in 1978 and formally adopted in 1982, the PRC's pollution levy system is now in use in most provinces and in the cities. In theory, if the levy is high enough, firms facing high costs to reduce pollution opt to pay the levy while firms facing lower costs opt to treat the pollution, until the point where the additional cost of pollution abatement equals the per ton value of the levy.

The levy system was created to fund local environmental protection bureaus (EPBs) and help finance a mechanism for financing a portion of pollution control—not to enforce pollution standards. In 1993, the government initiated a pilot in nine cities in which the levy rate was increased fivefold and the levy was applied to total emissions. In 2000, the basis for calculating the levy was changed to total emissions.

Despite recent increases, the levy rate is still low, estimated to be no more than half of the marginal abatement costs in most cases. The low rate, combined with the historical 80% recycling back to enterprises for pollution abatement, creates only limited incentives to reduce emissions. Enforcement is another issue. Although the emissions standards were set uniformly by the central government, local governments are in charge of collecting the fees. The local collections are quite sensitive to local environmental and economic conditions.[2] Emissions fees in the late 1990s were generally collected only from profitable enterprises, and reportedly, the fee amount could still be negotiated with local EPBs.[3]

Although the debate continues in the academic literature, augmenting the levy system with a strengthened command-and-control system is not likely to be a particularly efficient approach for achieving major reductions in emissions.[4] In general, command-and-control systems force firms to take on similar shares of the pollution control burden (that is, a uniform percentage reduction), regardless of cost. Although such approaches have some advantages, particularly with regard to actual or perceived simplicity, they can be quite expensive. Indeed, almost 20 years ago a survey of empirical simulation studies of air pollution control in the United States found that the estimated aggregate costs of control via conventional approaches exceeded the least-cost benchmarks applied to the same facilities by as much as 2,000%![5]

Emissions trading is an alternative to command-and-control that builds upon the highly successful U.S. experience with acid rain. As described in subsequent chapters, the particular form of emissions trading developed for Taiyuan is known as a cap-and-trade system. In contrast to the levy system, which in theory relies on price signals to induce reductions in emissions, a trading system sets emissions quantity targets, distributes permits to the emitting firms, and allows the trading of the permits among the firms in the system. Researchers have documented savings from the use of emissions trading to manage acid rain in the United States at 40% or more of the cost of conventional approaches.

One potential benefit of emissions trading is that, in effect, the sources with higher marginal abatement costs pay the sources with lower marginal abatement costs to clean up. This tradeoff has important efficiency and distribution implications. It provides benefits to society because low-cost sources carry out the required emissions reductions. High-cost sources benefit because they can pay the low-cost sources less than it would cost to make the reductions on their own.

Low-cost sources benefit by receiving compensation from high-cost sources for their excess reductions. This compensation helps offset the costs of control technologies or process changes. The result is attainment of the overall emissions goal at a lower cost to society. Emissions trading also creates flexibility in the timing of compliance, smoothing out pollution control investment needs through emissions banking, a form of intertemporal trading. For all these reasons, emissions trading has the potential to be an attractive instrument for environmental management, particularly in a country that, like the PRC, contemplates making major new pollution control investments in the coming years.

The challenge is to apply these techniques in a nation where legal and institutional arrangements for environmental management are still in their formative stages. Although the PRC is a rapidly evolving market economy, it has little experience with rigorous environmental monitoring and enforcement with respect to firms operating in such an economy, or with trading in complex markets of intangible commodities like pollution credits. Steady, reliable, fair enforcement and a well-designed program to detect and act on violations are basic building blocks of any environmental management system, whether that system uses conventional tools, levies, or market-based instruments. This TA has accorded high priority to identifying gaps in all areas of the environmental management system and in helping to fill those gaps. For example, training was provided on various aspects of monitoring, reporting, and enforcement. Further, a user-friendly emissions tracking system was developed expressly for the purpose of overcoming some of the perceived deficiencies in monitoring and reporting.

Why Taiyuan?

Taiyuan, the capital of Shanxi Province, was selected by provincial officials as the site of the demonstration for this project. Taiyuan is in a heavily industrialized area and one of the most polluted cities in Shanxi Province. Industry accounts for about 70% of a provincial gross domestic product (GDP) based largely on coal mining, coke production, iron-and-steel and other metallurgical industries, construction materials such as cement, chemical manufacturing, and ceramics. The province produces about one-third of the nation's total coal. Similarly, approximately 70% of the annual provincial energy resources in the form of coal, coke, and electrical power are exported for sale outside the province. State-owned enterprises account for about 70% of the industrial output, although many of these enterprises are moving to privatize.

Taiyuan is located 500 kilometers southwest of Beijing. It comprises the central city, the autonomous subcity Gujiao, three counties, and six districts. It has a population of 2.7 million and covers an area of 6,909 square kilometers. About two-thirds of the population lives in the 2% of the land area that constitutes the city proper. The mountains that surround Taiyuan on three sides create a natural smog trap in which air pollutants tend to accumulate.

The annual daily SO_2 concentrations in Taiyuan averaged 0.2 mg/m^3 in 2000 (see Table 1.1 for annual average SO_2 concentrations in Taiyuan in 1991–2000), much higher than the PRC's Class II annual standard (0.06 mg/m^3). Although subject to considerable year-to-year variation, official figures suggest that the trend in SO_2 concentrations has been relatively flat over the past decade. With recent economic growth averaging 10% per year, the apparent absence of deterioration in air quality reflects the considerable effort that has already been devoted to environmental improvement. At the same time, the relatively high SO_2 levels indicate the magnitude of

TABLE 1.1

Annual Average Daily SO_2 Concentrations in Taiyuan for 1991–2000 (mg/m^3)

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0.277	0.303	0.153	0.169	0.211	0.212	0.248	0.276	0.272	0.200

the challenge that lies ahead as Shanxi strives to increase its economic output and, at the same time, meet the major emissions reduction goals established in the Tenth Five-Year Plan.

In addition to the high SO_2 levels in the area, Taiyuan was selected as the location of the demonstration for several other reasons.

- Since ADB had just made a major loan to the province (and the city) for investments in air pollution control technologies, there is a unique opportunity to integrate these efforts into an improved air quality management system.
- Provincial and local officials expressed strong interest in participating in a demonstration.
- A high degree of technical support is available in the local government and other local institutions.
- A number of large enterprises expressed interest in participating in a demonstration.
- Various technical factors make it an attractive site, such as the availability of monitoring information; ongoing modeling activities (independently conducted by RFF and the Norwegian Institute for Air Research; the diversity of industrial sources; and the variability in the sulfur content of coal used in the area.

Why SO_2?

Researchers in the United States, Europe, and the PRC have identified SO_2 emissions as a particularly potent air pollutant, both as a gas and as fine particulates (sulfates). It is also relatively easy to measure and monitor, and an emissions trading system for SO_2 has already been successfully developed and implemented elsewhere, notably the U.S. SO_2 Allowance Trading System.

To examine how a major reduction of SO_2 emissions could affect health in Taiyuan, we developed some rough estimates of health benefits by (1) establishing the expected amount of SO_2 emissions reductions implied by a proposed cap on such emissions; (2) identifying the major types of damages (morbidity, mortality, other); (3) establishing the physical relationships between the pollutant emissions and the extent of different types of damages; (4) identifying the responses by affected parties to mitigate some (or all) of the damages; and (5) placing a monetary value on the physical damages, including the damages to human health.

Our approach relies heavily on a concentration-response function developed by the Harvard Institute for International Development in its analysis of health benefits in neighboring Shaanxi Province.[6] A great many extrapolations and assumptions are involved in developing this model and tailoring it to the situation in Taiyuan. The full set of extrapolations and assumptions is discussed in Appendix 2. Our calculations are keyed to the attainment of the Class I standards in Taiyuan. Overall, it is our judgment that attainment of the standards could avert between 402 and 1,886 deaths annually in Taiyuan. In monetary terms, the benefits of such reduction in air

pollution are estimated to range between 925 million Chinese yuan (CY) — equivalent to USD 115 million — and 4.3 billion CY — equivalent to USD 0.5 billion — annually. (See Appendix 2 for details of the model and the assumptions used to derive these estimates.) As another comparison, the proposed lump-sum investment in environmental projects in the Tenth Five-Year Plan is 700 billion CY (equivalent to USD 87.5 billion), which accounts for 1.3% of total GDP in the corresponding period.

Major Milestones

In preparation for the time when a full-scale emissions trading system would become functional in Taiyuan, several specific milestones were achieved over the course of this TA:

- education of government and industry leaders about the benefits of adopting emissions trading in Shanxi Province and Taiyuan City;
- establishment of facility-specific emissions caps for large emissions sources for the years 2002–05;
- promulgation by Taiyuan City in October 2002 of a formal regulation on emissions trading and the administrative framework to support the regulation;
- development and demonstration of various computer-based tools designed to facilitate emissions monitoring and verification (the emissions tracking system) and allowances management (the allowance tracking system) of the emissions trading system;
- extensive capacity building and training in the theory, practice, and management of emissions trading systems, for both government and industry, including senior officials as well as technical and managerial staff; and
- initial simulation of emissions trading among selected facilities (two large power plants, a small power plant, and a heavy machinery manufacturer).

Overall, the RFF team believes that this TA has succeeded in laying the foundation for effective and efficient SO_2 control in Taiyuan and developing the emissions trading model to the point that other areas of Shanxi Province can adopt it. Whether or when this system becomes fully operational remains to be seen. Continued support by both domestic and international experts to facilitate the initial operation and help ease the "growing pains" of the system is recommended, as is a further evaluation of the system when it reaches full-scale operation. Sixteen specific recommendations to advance the use of emissions trading in Taiyuan and elsewhere in Shanxi Province are presented in the Executive Summary and in Chapter Six.

Outline of Report

This final report is designed to convey the framework, structure, and operation of the emissions trading system in Taiyuan, as developed in this TA. Chapter Two presents the essential background, including information on the environmental management structure, legal system, compliance, and institutional framework in Taiyuan, along with an outline of the monitoring system in the city. Chapter Three considers alternative market-based instruments that might be

adopted in Taiyuan and presents the rationale for the type of cap-and-trade system selected. Chapter Four presents the specific design choices made for the demonstration in Taiyuan. It also outlines the elements of the SO_2 emissions trading regulation adopted by the city government in fall 2002. Chapter Five describes the responsibilities of the local EPB and enterprises participating in the trading program and the results and evaluation of an emissions trading simulation undertaken to support the Taiyuan program. Chapter Six summarizes the major accomplishments of the TA, discusses the continuing challenges to operationalizing the Taiyuan emissions trading system, and presents sixteen specific recommendations to advance the use of emissions trading in Taiyuan and elsewhere in Shanxi Province. Eleven appendices support the materials presented in the individual chapters.

■ ■ ■

CHAPTER TWO

Institutional Context

No environmental policy can exist in an institutional vacuum. Rather, environmental policies—like all others—operate in a context consisting of laws, regulations, government and industry behavior, and even cultural norms. Environmental policy in the PRC has evolved a great deal in the past decade. Of particular relevance to the current institutional context are the PRC's Law on Atmospheric Pollution Prevention and Control, the Tenth Five-Year Plan, regional and local regulations, practices and targets for improving the air, and the structure and functioning of the local environmental protection bureau.

This chapter considers this institutional context as background to conducting TA-3325. Specifically, the first section describes national air pollution policies in the PRC. The second section surveys the air pollution control context for Shanxi and, specifically, for Taiyuan. The third section reviews the history of the pollution permits system in Taiyuan, leading to the initiation of this TA. The fourth section examines the management context within the Taiyuan Environmental Protection Bureau (TEPB) for controlling pollution in the city.

National Policy

The first subpart of this section describes the PRC's Law on Atmospheric Pollution Prevention and Control (the Air Act). The second subpart describes the two basic state policies to control SO_2 emissions. The third subpart describes the overall process for the Tenth Five-Year Plan.

The Air Act

The basic authority for air pollution control is contained in the PRC Air Act.[7] The Air Act, passed in 2000, is a "framework" environmental law. It provides in very broad, general terms the outlines of the Chinese approach to controlling emissions. It identifies "key cities for air pollution control," of which Taiyuan is one. It requires the government to establish plans to control or gradually reduce the total maximum annual load of air pollution emissions for jurisdictions yet to be specified by the State Council, but which will likely include Taiyuan.[8] The State Environmental Protection Administration (SEPA) has the responsibility to prepare implementing regulations or sublaws, which it must submit to the State Council. The implementing regulations are to include language encouraging the use of emissions trading. The detailed commentary on enforcement provisions of the Air Act is contained in Appendix 3 of this report. Dis-

cussion of relevant legal issues surrounding the implementation of emissions trading in Taiyuan is contained in Appendix 4.

Total Emissions Control and Two Control Zones

"Total Emissions Control" and "Two Control Zones" are the two basic state policies to control SO_2 emissions in the PRC. The concept of Total Emissions Control (TEC) was introduced in the Ninth Five-Year Plan (covering 1996–2000) and formally enshrined in the Air Act in 2000. Currently, it is in the process of being implemented. The TEC plan caps total emissions of 12 air, water, and solid waste pollutants (including SO_2) in certain geographical areas. Selected cities are requested to establish rules for TEC to support targets for environmental improvement. The plan also directs that as industry restructures, it must consider cleaner production techniques and pay attention to the entire production process, not just end-of-pipe pollution. Certain backward production processes and obsolete equipment are targeted for replacement. The plan makes resource conservation a priority. The plan also directs that the capacity of major environmental management institutions be strengthened. Priority is to be given to measurement of emissions and enforcement of regulations. Supervisory and enforcement personnel are mandated to upgrade equipment. Automated air quality monitoring networks are planned for large and medium-sized cities, including Taiyuan, and continuous emissions monitors (CEMs) are being mandated for new large emissions sources.

In January 1998, the State Council approved an ambitious plan originally proposed by SEPA for the control of acid rain and SO_2 emissions in the most seriously affected regions, designated the "Two Control Zones." The acid rain and SO_2 control zones together cover about 11% of China's territory and are responsible for 60% of China's total SO_2 emissions. One of China's overall goals for these zones for the year 2010 is to bring all cities into compliance with ambient air quality standards. Shanxi was listed as one of most seriously polluted SO_2 emissions control areas.

Tenth Five-Year Plan

The PRC engages in a planning process every five years to set priorities and direction for its economic development, including environmental priorities and objectives. These are set first at the national level and later at provincial and local levels. The Tenth Five-Year Plan covers the period 2001–05.

The Tenth Five-Year Plan establishes specific targets for pollution control at the regional and local levels. Overall, by 2005 the PRC aims to reduce SO_2 emissions nationwide to 10% below 2000 levels, or 17.96 million tons. For the two acid rain and SO_2 control zones, SO_2 emissions are targeted at 20% below 2000 levels by 2005, or 10.53 million tons. Provinces and autonomous municipalities are also allocated SO_2 emissions targets under the plan, with the goal of achieving reductions between 1.5% and 20.5%.

Air Pollution Control in Shanxi and Taiyuan

It is estimated that total SO_2 emissions in Shanxi Province will reach 1.575 million tons by 2005 in the absence of further policy initiatives. The goal set in the province's Tenth Five-Year Plan is 1.1 million tons during the same period. The specific targets for 2005 for major cities in Shanxi

TABLE 2.1

SO_2 Emissions and TEC Objectives for Major Cities in Shanxi in Tenth Five-Year Plan

	2000 emissions (tons)	2005 TEC level (tons)
Taiyuan (city plus 3 counties)	295,000	200,000
Taiyuan (SO_2 control zone)	258,000	125,100
Datong	160,000	150,000
Yangquan	140,000	130,000
Shanxi Province	1,575,000	1,100,000

Province are shown in Table 2.1. Note that by far the largest reductions are slated for the SO_2 control zone of Taiyuan: a full 50% drop below 2000 levels.

As Shanxi strives to meet its emissions and TEC objectives under the Tenth Five-Year Plan, it has focused on four overall strategies:

- Require industry to meet applicable standards on a continuous basis (not just intermittently).
- Increase enterprise commitment to cleaner production.
- Implement a pollutant permit system based on mass emissions from facilities.[9]
- Strengthen environmental management systems.

Specifically, in response to the demands of the Tenth Five-Year Plan, officials of Shanxi Province are engaged in extensive planning to reduce SO_2 and other pollutants. The elements of this effort include special attention to coal mining and coal use, which are, as noted, the major source of SO_2 emissions in Taiyuan. By way of background, it is noteworthy that some of the cleanest coal is currently being diverted away from Taiyuan to Beijing, where the sulfur content of coal burned in the city is required to be less than 0.5%. As a result, limited quantities of very-low-sulfur coal are currently available in Shanxi Province. The Office on the Controlled Regions of Acid Precipitation and SO_2 Pollution (approved by the State Council) required that coal mines with a sulfur content greater than 3% be closed. Several mines plan to reduce sulfur content by coal washing, and it is expected that approximately 8% of coal will be washed. The "No Coal Region" policy was implemented starting in 2002 in Taiyuan. Currently, there are three small No Coal Regions established in three districts of Taiyuan, covering a total area of 3 km^2. The national plan includes a requirement to close thermal power stations under 6MW and to close those under 25MW that are at the end of their design life.

Taiyuan Environmental Protection Bureau officials have indicated that cost is the most important consideration in deciding which sources to control. The Tenth Five-Year Plan of Taiyuan includes 52 projects from 2001 to 2005 with a total investment of 6.5 billion renminbi (RMB). These projects include not only the plant-level pollution control projects but also some nature conservation and infrastructure projects. (Table 2.2 summarizes the major air pollution control activities planned for Taiyuan in the Tenth Five-Year Plan.) The goals of the Tenth Five-Year

TABLE 2.2

Emissions Control Planned for Taiyuan 2001–05

Project	*Date*	*Investment Costs (RMB)*	*Pollutant Reduction (T/yr)* SO_2	TSP	*General Information*
Taiyuan Chemical Group	2001	NA	951	——	Cleaner production
Municipal Coal Gas	2001	247,400,000	3,200	980	Increase coal gas production
Power plants	2001	NA	49,047	——	Change from high-sulfur to low-sulfur coal
Domestic boilers	2001	NA	19,264 (winter) 3,680 (other)	——	Change from high-sulfur to low-sulfur coal
Industrial boilers	2001	NA	22,080	——	Change from high-sulfur to low-sulfur coal
Brick making	2001	NA	3,680	——	Change from high-sulfur to low-sulfur coal
Mid- and large-scale boilers	2001	53,440,000	8,119	——	Install FGD at - boilers from 10 to 35 tons/hr.
Power Plant 1	2001	NA	23,708	——	Retire boilers 1 to 10
Taiyuan Iron & Steel	2002	50,000,000	2,000	2,000	Cleaner production
Various locations	2002	——	4,000	3,000 (smoke), 2,000 (process)	Close backward technologies
Power Plant 2	2003	189,280,000	3,097	3,611	Cogeneration
Municipal Coal Gas	2003	1,128,690	6,600	2,100	Cogeneration
Taiyuan Iron & Steel	2004	50,000,000	2,000	2,000	Cleaner production
District heating	——	Unknown	4,537	5,290	District heating
Power Plant 1	2005	150,000,000	17,827	——	FGD
Power Plant 2	2005	Unknown	36,188	——	FGD
Power Plant 2	2005	——	8,095	5,256	Retire three boilers
Taiyuan Iron & Steel	2005	451,000,000	9,650	5,050	Cleaner production
New energy sources	2005	440,000,000	8,269	11,232	Coal bed methane, etc.
Power Plant 1	After 2005	75,000,000	8,900	——	Boiler renovation
Power Plant 2	After 2005	53,000,000	23,561	——	Renovate boilers 2–6
Other gas conversion	After 2005	NA	1,741	——	Municipal coal to
Other	After 2005	440,000,000	8,269	——	Coalbed gas
Other	After 2005	778,400,000	12,892	——	Cogeneration
Other	After 2005	NA	5,627	——	District heating

Note: FGD = flue gas desulfurization; TSP = Total suspended particulates

plan do not leave much room for new industries or sources. However, Shanxi officials expect that new sources would engage in emissions trading to offset their emissions.

Power plants are required to upgrade their sulfur removal technologies by, for example, mixing limestone with the coal prior to combustion or installing flue gas desulfurization (FGD). All boilers with thermal capacity greater than 10 tons of steam per hour are required to use coal with sulfur content not greater than 1%. Both of the large power plants in Taiyuan have closed several small boilers. These actions are expected to reduce coal consumption by 1 million tons and reduce sulfur dioxide emissions by approximately 24,000 tons annually.

During the period of the Tenth Five-Year Plan, Taiyuan Iron & Steel plans a 10% reduction in overall output, although stainless steel production will increase. Certain facilities may be relocated as part of a long-range plan to move the operations out of the city. Also during this period, the percentage of clean energy will be increased and the management of harmful chemical releases and radiation will be strengthened. New measures to control vehicular pollution in the city include phasing out old taxies and buses and eliminating or converting to other energy sources.[10]

Taiyuan's Early Efforts with Trading and Other Air Pollution Policy

The Taiyuan City government began experimenting with emissions permits and Total Emissions Control beginning in the 1980s. As early as 1985, limited emissions controls were required. To control the deteriorating urban air quality, Taiyuan City established a series of local laws and regulations, including Total Emissions Control Standards for Air Pollutants. Following the principle of "increasing output without increasing pollution, and building new facilities to replace the old ones," the city conducted pilot experiments on emissions trading and emissions offsets in the mid-1990s. More recently, this has encouraged enterprises to conduct various analyses of the cost-effectiveness of alternative types of emissions controls.[11]

In 1993, a regulation entitled Rules on Environmental Offsets for Air Pollutants was issued as the legal basis for pilot emissions trading. In 1998, the city government issued Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City, which also included a provision for "permit exchange," a form of emissions permit trading. On the basis of this regulation, TEPB experimented by issuing updated permits with TEC-based limits to large enterprises. Between 1994 and 1997, 40 key enterprises were issued air pollutant permits by TEPB. Unfortunately, these permits were for a limited period of time (two to three years), and all have now expired. Emissions are being enforced by "target responsibility agreements," which are essentially a series of written agreements or contracts detailing the responsibilities of government and enterprises for environmental quality.[12]

In 1999, the Taiyuan government announced new initiatives for air pollution control. These seek to reduce coal use in the central urban area by requiring fuel switching, closing of certain small boilers, installation of monitoring devices, and emissions controls on larger boilers.[13] With assistance from ADB, the urban gas supply system is being expanded, and the district heating system is slated for modernization: it will use heat from the larger power stations in the city to replace community boilers. The heating sources are in place, but the local service area is still limited; a significant investment will be required to expand the local heat distribution

TABLE 2.3

Major Policy and Regulatory Developments Related to Air Emissions Permits

Year	Activity
1985	Taiyuan government issues air emissions control management rule requiring facility modifications to meet emissions standards.
1987	National Air Pollution Prevention and Control Law approved.
1991–97	National pilot program for emissions permits supervised by SEPA.
1993	Taiyuan City government issues "Rules on Environmental Offsets for Air Pollutants," which starts the pilot of emissions trading in Taiyuan.
1995	National Air Pollution law amended.
1996	State Council issues Decision Regarding Several Issues of Environmental Protection (Guofa No. 31, 1996); State Council approves Total Emissions Control Plan for Major Pollutants.
1998	State Council approves National Acid Rain and SO_2 Control Zoning Plan; Taiyuan City government issues Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City, including provision for "permit exchange."
1999	Taiyuan City government announces new initiatives for air pollution control and countermeasures; new TEC-based permits issued for major pollution sources.
2000	National air pollution law amendments approved, with more stringent enforcement provisions and provisions for emissions trading, but requires national implementing regulations to be effective.

network. Legislative and regulatory developments pertaining to the emissions permit program in Taiyuan are summarized in Table 2.3.

In March 2001, the RFF team inspected a number of permits in the offices of TEPB (see Box 1 for sample permit descriptions). Based on this review, the recent permit system appears to be a clear improvement over the early pollution source registration "permits" because it specifies specify the obligations of the major polluting enterprises and combines TEC limits with other regulatory criteria. The system has several other advantages, but also significant limitations.[14]

The strengths and weaknesses of the permit system are summarized in Table 2.6 (page 31).

BOX 2.4: EXAMPLES OF PERMITS

Taiyuan Iron & Steel Company ("Tai Gang"). Tai Gang's permit prescribes an annual limit for SO_2 and total suspended particulates (TSP). For major process units (such as on-site power plant, boilers, industrial furnaces and kilns), raw material and energy inputs are listed and allowable emissions for each unit are calculated based on the formulae contained in the applicable GuoBiao, or national standard (some deviations from this calculated allowable can be made, for example the BAPT basis noted above). The allowable amounts form the basis for the total amount listed in the permit.

Tai Gang's permit defines an internal SO_2 bubble for the power plant. The permit also appears to define a bubble for the entire facility. The permit was issued in 1999, with a three-year period of effectiveness. The annual allowable SO_2 limit, currently about 25,500 tons per year, is less than the 1997 emissions of 29,032 tons per year, suggesting that the permit was in effect "grandfathering" the typical annual emissions rather than requiring a major reduction. Although the current permit may not have required major reductions in emissions, renewal of the permit in 2002 will provide an opportunity for imposing new reductions.

Taiyuan Coal Gasification Group Corporation, Limited (TCG) is the largest source of gas for the urban gas supply system. TCG's annual SO_2 limit is 6,239 tons per year and current monitored emissions are 5,759 tons per year. The annual limit includes emissions from the coke production plant and the on-site power plant (coal *gangue*-fired 2×12MW combined cycle cogeneration design; allowable SO_2 emissions for the power plant are greater than 2,000 tons per year, but a specific number was not provided).

Notably, TCG's permit does not include fugitive emissions from the coke production units. Based on annual coal consumption of 1 million tons and sulfur content of 0.6%, the coke production should generate 9,600 tons per year SO_2 (using SEPA's accepted formula). Assuming that the power plant emits 2,000 tons per year and that total monitored emissions are 5,759 tons, then 3,739 tons of SO_2 is emitted through the coke unit stacks, with 5,841 tons of fugitive emissions.

TCG also stated that the company paid CY 1 million in pollution levies to TEPB during the year 2000, with CY 400,000 paid for SO_2 and CY 600,000 paid for wastewater discharge. (The company is rebated 80% of the levies paid.) Based on SO_2 emissions of 5,759 tons per year, the SO_2 levy paid should be CY 1,151,800.

Note: Previously, payments of levies were made to both local and provincial EPBs. This appears to be more complicated than necessary. In early 2001, SEPA approved changes in the pollution levy system, including a provision for levies to be paid directly to financial institutions under Ministry of Finance supervision. This simplification of levy payments should help promote better tracking and coordination between the EPBs' permit issuing units and levy collection units.

Structure of Institutions for Environmental Management in Taiyuan

The lead agency for implementing air pollution policy in Taiyuan is the Taiyuan Environment Protection Bureau, established in 1979 as one of the components of Taiyuan municipal government. The first two subparts of this section describe the current functions and responsibilities of the offices and divisions within TEPB that are most relevant to this project, including the Environmental Monitoring Center. The third subpart of this section describes the status of the current monitoring system in Taiyuan.

General Information

TEPB has the following 12 offices *(see Box 2.5 for formal organizational chart):*

- Office of General Affairs
- Planning and Financial Division
- Water Pollution Control Division
- Technological Standards Division
- Division of Human Resources
- Chinese Central Party (CCP) Office
- Development and Supervision Division
- Air Pollution Control Division
- Nature and Ecological Protection Division
- Policies and Regulations Division
- Office of Environmental Inspection
- Office for Retired Staff

Other units affiliated with TEPB include the Taiyuan Station of China Environment News and Environmental Information Center, the Emission Supervision and Management Institute, the Taiyuan Environmental Monitoring Center, and the Taiyuan Institute for Environmental Sciences. A total of 518 staff are employed within the system.

The budget of TEPB mainly comes from three sources: (1) the municipal financial bureau, which allocates funds according to the number of staff members in TEPB; (2) pollution fees, which are collected by TEPB, paid into the municipal government, and then partially reallocated to TEPB as special funds; and (3) the provincial EPB, which allocates special funds to TEPB.

Offices Most Relevant to the Implementation of Emissions Trading

The responsibilities and functional scope of each of the main offices and affiliated institutions particularly relevant to the implementation of the emissions trading program in Taiyuan are highlighted below (further description of TEPB is presented in Appendix 5):

- **The Planning and Financial Division** formulates the city's environmental protection plan; identifies and supervises implementation of environmental protection in the city; and takes part in municipal economic and social development planning, land development, and regional economic development planning. The division organizes Total Emissions Control planning; supervises the renovation and inspection of enterprises; supervises environmental monitoring, statistical work, and information collection; and compiles and issues the municipal environmental quality report, environmental status report, and environmental annual report. Additional responsibilities of the division include formulation of the investment plan and balancing the investment and environmental subsidy, and responsibility for financial management and supervision of revenue and expenditure for emissions charges and environmental funds. The Planning

BOX 2.5: ORGANIZATIONAL CHART OF TAIYUAN ENVIRONMENTAL PROTECTION BUREAU

TEPB

Professional Divisions

- Air Pollution Control Division
- Water Pollution Control Division
- Development & Supervision Division
- Science & Standards Division
- Nature & Ecological Protection Division

Office of General Affairs

- Planning & Financial Division
- Policies & Regulation Division
- Technological Standards Division
- Division of Human Resources
- Office of Retired Staff
- Chinese Central Party Office

Attached Units

- Taiyuan Municipal Environmental Monitoring Center
- Environmental Design & Research Institute
- Institute for Environmental Management and PLS Supervision

TABLE 2.6

Strengths and Weaknesses of the Emissions Permit System

Strengths	*Weaknesses*
System provides formal and systematic basis for industrial emissions control and future reductions via permit renewal.	TEPB has limited resources to conduct monitoring for systematic and independent compliance assurance.
Permit form is flexible to provide in-plant bubbles and daily or hourly mass emissions limits.	Pollution levy previously allowed enterprises to pollute in excess of national standards, provided they paid fees.
Monitoring provisions are referenced in applicable national standards.	"Double-burden requirement," when economic development and environmental protection come into conflict, can have pernicious impact.
Financial penalty for noncompliance is defined.	Financial penalties are insufficient in themselves to promote investment in cleaner production, but return of 80% of the levies collected finances a portion of pollution control investment.
Enforcement of permit limits is supported by other major environmental policy instruments.	Levy collection is not linked directly to permit conditions.
	Fugitive emissions are not included in permits.

and Financial Division also organizes and conducts international communication in environmental protection and the introduction of foreign investment, technologies, and environmental protection projects; and is in charge of the financial management and the internal audit of the units directly under the administration of TEPB.

- **The Policies and Regulations Division** prepares local environmental protection legislation, administrative regulations, and implementation approaches; studies environmental polices; investigates and resolves severe pollution events and ecosystem loss; and deals with severe transcounty and transcity environmental disputes. The division is also responsible for punishing environmental pollution, reviewing administrative decisions, responding to administrative lawsuits, and organizing governments of different levels in the city to implement the national, provincial, and municipal environmental protection laws and regulations.

- **The Air Pollution Control Division** is responsible for the management of industrial air pollution and noise pollution; drafts local regulations on air pollution and noise pollution control; implements the emissions permit system; and examines air pollution controls, Total Emissions Control, and the objective responsibility system in protecting the environment. The division also is responsible for suggestions on yearly plans for air pollution and noise pollution control, reviews control proposals, implements supervision, takes responsibility for construction and management of the soot control region and the noise control region, and guides and supervises traffic emissions control.

- **Institute for Environmental Management and Pollution Levy System Supervision** is responsible for implementing state and local laws, regulations, and policies on environmental protection; carrying out spot supervision and/or examination of enterprises and individuals; submitting the monitoring plan on emissions charge sources, registering and checking of emissions reports, and establishing emissions charge files; implementing the basic emissions charge for waste water and the emissions charge on waste water, waste gas, solid waste, and noise in excess of the permitted limits; managing emissions charges, compiling the yearly budget of emissions charges, and compiling and reporting work on emissions charges and the related statistical reports; investigating and assessing ecosystem damage events; supervising the operational status of pollution control facilities; responding to public complaints and investigating pollution events and pollution disputes; working on the five-year plan for pollution control and supervising implementation of the plan; training supervisory and management staff; and summarizing experiences in environmental management.

- **Taiyuan Municipal Environmental Monitoring Center** is responsible for monitoring and reporting on air quality. Its procedures for ambient monitoring of air quality follow national requirements, and it processes data by computer using methodologies consistent with technological regulations on environmental quality reporting and national regulations on environmental monitoring. The center conducts some facility-specific monitoring. The center also performs such monitoring tasks as the quantitative examination of the municipal comprehensive renovation made by the national, provincial, or municipal government; the municipal objective responsibility system; the objective responsibility system in industry and enterprises; air and water emissions permission licenses; and so forth. The division mediates arbitration on pollution events and disputes, environmental impact evaluation of projects, the approval of environmen-

tal protection facilities, and the identification of new products as entrusted by the governing bodies. The division compiles monthly, quarterly, and yearly reports on environmental quality for air quality, water body quality, noise, and industrial pollution sources.

Status of Monitoring in Taiyuan

There are seven stations for regular air monitoring in Taiyuan: Shanglan, Xing'an, the State Defense Office, Taoyuan, Taihang, Power Plant 1, and Xiaodian. Among them, Shanglan serves as the control spot for regional background and is not counted in calculating the city average. There are 12 monitoring locations for dust precipitation and the formation of sulfates, and 3 locations for monitoring atmospheric precipitation.

With the exception of the Shanglan station, which provides background information, all monitoring locations use the auto-sampling system to monitor SO_2, nitrogen dioxide (NO_2), and carbon monoxide (CO) continuously (24 hours a day and 365 days a year). In Shanglan, the three pollutants are measured four times per day on five days each year by manual sampling. The monitoring of dust precipitation and the rate of sulfate formation is conducted on a yearly basis.

Enterprises are monitored by the Taiyuan Environmental Monitoring Center according to the scale of plant and national management requirements. Boilers (including boilers in power plants) that are used year-round are monitored once a quarter. Boilers used for heating are monitored once a year in their operational period. The rules require that measurement for ash composition and sulfur content be carried out once a month.

In addition, there are some requirements for self-monitoring. Boilers, including boilers in power plants that are used year-round for the purpose of production, are required to be monitored four times a year. Monitoring is required twice a year for boilers used for heating, and measurements for ash composition and sulfur content must be taken three times a month. Enterprises that can measure their emissions are asked to report the measured data to TEPB once a quarter.

Where enterprises self-monitor, the results from the Municipal Environmental Monitoring Station and the results from the enterprise itself are combined into a final total emission using the following formula: a weighted average with 30% of the result from the enterprises and 70% of the TEPB monitoring result. If an enterprise does not have the ability to measure its emissions, the result from the municipal Environmental Monitoring Station is treated as the final value.

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CHAPTER THREE

Rationale for a Cap-and-Trade System in Taiyuan

This chapter discusses the rationale for selecting a cap-and-trade form of emissions trading in Taiyuan, rather than emissions "offsets," or an open market trading system, or even an increase in the levy. Overall, a cap-and-trade approach was selected for demonstration for three reasons:

- Cap-and-trade systems provide greater environmental certainty than other approaches.
- The already-announced TEC policy requires local governments to set emissions targets, which can then serve as caps for the cap-and-trade policy.
- There is growing interest at the national and provincial levels in introducing cap-and-trade systems throughout the PRC.

The first section of this chapter considers the alternative types of trading systems available for the Taiyuan demonstration, a characterization of the strengths and weaknesses of each, and a brief review of some of the international experiences with these approaches. The second section presents information on the national policy context for market-based instruments in the PRC, with a focus on recent developments at SEPA relevant to the adoption of a cap-and-trade system.

The third section reviews the current situation in Taiyuan, including the consideration of a "permits exchange" idea prior to this TA, as well as available information on abatement costs and technology options in the PRC and, particularly, in Taiyuan. The overall goal of this review is to examine the prospects for significant cost savings under a market-driven allocation of emissions reduction responsibilities, as opposed to other approaches for managing pollution.

Forms of Emissions Trading

Three types of emissions trading approaches were considered for the Taiyuan demonstration: emissions "offsets," open-market trading system, and cap-and-trade. Since structurally different emissions trading programs are often identified in different ways, the names alone are not sufficient to characterize the programs. Rather, it is important to identify their key attributes, such as whether emissions are capped or uncapped. Below, we introduce each approach and of-

fer a brief description of its pros and cons, starting with the program that requires the least government supervision and ending with the one that requires the most.

For all these forms of emissions trading, if permits are given away (typically grandfathered) rather than sold, industry retains more financial resources because payments associated with buying and selling allowances flow from one enterprise to another, not to the government. Enterprises must still finance actions to control emissions, but they do not, in addition, need to pay the government for those emissions. Moreover, in choosing emissions control activities, enterprises are free to use the emissions-reducing options they find most cost-effective, whether end-of-pipe or otherwise. They do not need to seek prior approval from government authorities, as in the case of recycled charge revenues in the PRC. Nor do environmental authorities need to make any calculations of marginal control costs for different enterprises, as they would in determining an SO_2 levy.

The least-structured type of emissions trading system involves emissions offsets. Under an offset program, emissions reductions in one place are allowed to compensate for increased emissions somewhere else. Offsets can be between different plants (an "external offset") or between sources of emissions within the same plant ("internal offsets"). Typically, offsets are approved and implemented on a case-by-case basis. Offsets may involve financial compensation, but that is not an essential element. Emissions reductions from one source in excess of the proposed emissions increases at another may be required to achieve an overall net reduction in emissions (for example, a source may have to reduce two tons to offset one ton of increases at another source). Offsets can be useful for allowing new or expanded sources of pollution to locate or produce in a region that fails to meet its ambient targets or standards. In these cases, new sources may have the responsibility for obtaining (or paying for) emissions reductions from existing sources. Emissions offsets were among the first market-based instruments used in the United States, in the early years of the U.S. air management program. As discussed in the previous chapter, the PRC has experimented with offset programs in pilot projects, including in Taiyuan.

A more ambitious trading approach is the open-market trading system. A pollution source can earn marketable emissions credits by reducing its emissions to levels below a regulatory standard or by making reductions in advance of a prescribed deadline. For example, if an enterprise is subject to an emissions standard, and this standard exceeds its actual emissions, it may sell the amount of pollution reduction implied by the difference, depending on the rules of the particular system. The credits earned may be sold to other sources and used to offset an equal amount of excess emissions, and they may be resold as well, or they may be banked for future use. This approach institutionalizes the offset idea by permitting sources to trade without case-by-case approval. It reduces transaction costs relative to an offset system and has been implemented in a handful of states in the United States (and withdrawn in one of those states). The main difficulty with open-market trading systems is meeting an aggregate emissions reduction target, for it may be difficult to monitor all the credit-generating activities, and no overall limit on emissions is built into the design.

Still more ambitious, flexible, and demanding on the infrastructure is a cap-and-trade system, of which the U.S. SO_2 allowance trading system under the Clean Air Act is the canonical example. Sources in an area may trade pollution reduction responsibilities among themselves to meet an aggregate emissions cap set by the government. In this system, emissions credits (or allowances) are allocated without reference to a regulatory standard (although sources can still be

required to comply with certain standards in order to trade). Instead, the regulatory agency decides on the aggregate level of allowable emissions for all the parties participating in the program (the "cap"), and then allocates to each party a portion of this amount in the form of "allowances" that can be traded. Each allowance gives a source the right to discharge one unit of the pollutant in question. The allocation may be made according to parties' historical emissions, by auction, or by other means. Once allowances are allocated, parties are prohibited from emitting more pollution than their allocation unless they purchase additional allowances from another party.

Over the past decade, all three forms of emissions trading have been used in the United States. The sidebar on page 37 describes the experiences with the different U.S. programs involving both capped and uncapped approaches.

National Policy Context for Emissions Trading in the PRC

A cap-and-trade system for Taiyuan is consistent with national efforts already under way within the PRC to introduce a market-based approach to controlling SO_2 emissions. The PRC typically test pilots new approaches for environmental management before they are adopted for nationwide use. Recently, the State Environmental Protection Administration (SEPA) has made the development and piloting of SO_2 emissions trading programs a priority. As early as the 1980s, the PRC began discussing emissions trading pilots in combination with air quality management projects. For example, SEPA has carried out several academic case studies on the transfer of emissions allowances among enterprises. These studies created the opportunity to move beyond the conceptual phase and actually conduct pilot experiments with emissions trading. SEPA's interest in emissions trading continued to grow in the 1990s as it began working with international partners to help build local capacity for emissions trading. As part of the Ninth Five-Year Plan, the Total Emissions Control approach was discussed extensively. SEPA endorsed the Taiyuan demonstration and has clearly signaled the importance of this demonstration for the overall policy structure.

In 1994, SEPA carried out emissions trading policy pilots in six cities: Baotou, Kaiyuan, Taiyuan, Liuzhou, Pingdingshan, and Guiyang. The pilots introduced flexibility into the emissions control requirements and enabled enterprises to transfer allowances within an enterprise, pay an environmental compensation fee to obtain additional emissions allowances, invest in non-point-source pollution controls to obtain additional emissions allowances, and sell surplus allowances to sources that hold insufficient allowances. In these pilots, the trading was heavily influenced by political considerations and was not strictly market driven. It worked in combination with new, expansion, and technical-innovation projects arranged by local environmental protection bureaus.

Other efforts to increase the knowledge and understanding of emissions trading include SEPA's partnering with the U.S. Environmental Protection Agency. In 1999, SEPA and U.S. EPA cooperated on a study to explore the feasibility of introducing nationwide SO_2 emissions trading in the Chinese power sector. This study explored the theory, methods, legal basis, and conditions of emissions trading and considered special conditions in PRC. Through various workshops and training activities, a number of Chinese management and research personnel

RECLAIM: The Regional Clean Air Incentives Market established by the South Coast Air Quality Management District (Los Angeles area) is a cap-and-trade program covering sources with four tons per year or more of NO_x or SO_x emissions and has the objective of reducing NO_x and SO_x emissions by 75% and 61%, respectively, from affected sources. RECLAIM trading credits are good for one pound of NO_x or SO_2.

Acid Rain Program: This cap-and-trade program seeks to control SO_2 emissions from coal-fired electric power plants (Phase I) and other major sources (Phase II). One allowance is good for one ton of emissions.

Emission Offsets: This program, whose principal features have been copied widely in other nations, allows the siting of new sources or the expansion of existing sources of emissions in areas that do not meet air quality goals. The new or expanding source must purchase emissions reduction credits from existing sources, reductions in emissions that have been recognized by the relevant local or state government air agency as being real, permanent, surplus, and enforceable. An offset ratio greater than 1:1 may be required to ensure some improvement in air quality. Offset programs are capped if total emissions are limited through the permitting process.

NO_x Budget Program: This program is a cap-and-trade program for summertime emissions of NO_x in the northeastern United States. Tons are the units traded.

Emissions Reduction Market System: ERMS is a cap-and-trade regulatory program in the northeastern Illinois ozone nonattainment area. It applies to stationary sources subject to Clean Air Act permitting that emit 10 tons or more of volatile organic material (VOM) per year. Sources receive an allocation of allotment trading units, each of which represents the right to release 200 pounds of VOM during the allotment period (May 1 through September 30). Sources may receive a program exemption if they accept a 15-ton per season cap on emissions or if they agree to limit emissions to 82% of baseline emissions. Sources in the program receive an allocation that is 12% lower than their baseline emissions, defined as the two highest-emission years during the 1994–96 period.

CFC Production Allowance Trading: A capped system of production allowances for chlorofluorocarbons (CFCs), under which the amount that could be produced was reduced each year. Rules promulgated by U.S. EPA specified that each time an allowance was traded, 1% of the allowance was retired from use.

Lead Credit Trading: From 1982 to 1985, refiners in the United States were allowed to trade credits for lead in gasoline to meet progressively more stringent limits on gasoline lead content. One credit was good for one gram of tetraethyl lead in this uncapped system.

Corporate Average Fuel Economy: A 1975 U.S. law requires that manufacturers of new automobiles satisfy efficiency standards expressed in miles per gallon of fuel. CAFE credits can be averaged by the manufacturer or traded between manufacturers. Because total fuel use depends upon how many vehicles are sold, fuel use (as well as carbon dioxide emissions) is uncapped.

Tier II Emissions Averaging: This new U.S. program permits manufacturers of automobiles to meet Tier II NO_x tailpipe standards by averaging or trading with other manufacturers. Because total emissions depend upon automobile sales, the total emissions are uncapped.

Open Market Trading: The Michigan Emissions Trading Program and similar programs in Connecticut, Massachusetts, New Hampshire, and Texas are outgrowths of U.S. EPA's proposed 1995 Open Market Trading Rule. Although the proposal was never finalized, it was incorporated in draft Economic Incentive Program Guidelines in 1999. The programs offer a variety of ways for sources to generate tradable credits from mobile and stationary source pollution control measures; however, there is no cap on overall emissions. The units traded are variously termed discrete emission reductions, discrete emission reduction credits, or open market credits. Unlike emission reduction credits, these credits are not evaluated or verified by the relevant local or state government air agency.

developed a deeper understanding of emissions trading. Most recently, a conference was held in Beijing to consider recent developments and future challenges.

Parallel to the Shanxi project, a project has been developed over a five-year period in collaboration with Environmental Defense, a U.S.–based nongovernmental organization. Environmental Defense has worked in two industrial cities: in Benxi to draft tougher air pollution legislation based on the U.S. acid rain model, and in Nantong to develop a demonstration SO_2 trade whereby a light manufacturer can expand operations in exchange for contributing funds for pollution control to a local power plant. The Nantong trade is quite similar to an emissions offset. Environmental Defense has also worked with the PRC's power sectors. Prominent Chinese environmental experts have been involved in these efforts, including researchers at the Chinese Research Academy for Environmental Science, Professor Ma Zhong of People's University in Beijing, and other universities and institutes.

In 2002, to gain more experience and facilitate nationwide adoption of emissions trading, SEPA organized pilot programs in seven provinces. After one year of preparatory work, some initial success has already been reported. For instance, two power plants in Jiangsu have reached an agreement to trade SO_2 allowances to meet TEC limits. SEPA *expects* to strengthen and expand these pilots in 2003 and beyond.

Conditions in Taiyuan

Cost Analysis and Technology Options

The extent of heterogeneity of marginal abatement costs among enterprises and the presence of economies of scale in pollution abatement are critical determinants of the suitability of an emissions trading system for addressing a particular environmental problem. In the formulation used here, these costs do not take into account the time of year the emissions occur, the location of the source, stack height, or other parameters that might affect actual human exposures.[15]

Specifically, emissions trading has the potential to smooth out differences among plants or locales in marginal abatement costs among emissions sources. Such cost heterogeneity may exist because of inherent differences in technical control options, fuel types, or other factors relevant to individual emissions sources. Cost heterogeneity may also exist—at least temporarily—because of the inherent "lumpiness" of many SO_2 control options vis-â-vis the time path for reductions stipulated in the regulation. Thus, if the regulation calls for a 50% emissions reduction staged in 10% increments over five years, some sources may install a control technology yielding the full 50% reduction early in the five-year period but others may wait until the fourth or fifth year. In that case, there would be an opportunity for emissions trading during the five-year transition period.

Another rationale for emissions trading is associated with economies of scale in pollution abatement. Suppose there are two identical sources, and one has control technology that can achieve 100% reduction in emissions at the same cost as another source that can achieve only 50% reduction. If both sources were required to reduce emissions by 50%, it would make sense for one of the sources to reduce its emissions completely and sell the excess reductions to the other source. Although situations involving large economies of scale in pollution abatement are rare, they have been recorded in the literature.[16]

TABLE 3.1

SO_2 Marginal Abatement Cost for Industrial Sectors (1995 data)

Industry	Releases in 1000t	Reduction Rate (%)	Abatement Cost (RMB)	MAC (RMB/ton)
Electricity, steam, and hot water	7,178	22	3,348	67
Building materials and nonmetal mineral products	1,232	10	5,039	479
Chemicals	1,180	75	15,782	3,004
Ferrous metals	840	16	54,507	867
Nonferrous metals	613	59	2,242	218
Food products	184	58	6,171	576

Source: Dasgupta, Susmita, and Hua Wang. 1997. *Surviving Success: Policy Reform and the Future of Industrial Production in China.* Washington, DC: World Bank.

Researchers have previously documented considerable cost heterogeneity among different industrial sources of SO_2 emissions in the PRC. For example, a recent study in the neighboring province of Shaanxi estimated potential cost savings of 50% or more for SO_2 reductions from the use of market-based instruments compared with additional command-and-control regulations.[17] In addition, data compiled by Dasgupta and Wang indicate that electric power and district heating systems, which are typically the largest sources of SO_2 emissions in the PRC, have lower incremental control costs than other sources (Table 3.1). Based on this analysis, a least-cost solution would involve greater relative control by low-cost sources, such as electric power plants and nonferrous metal fabricators, and relatively less control at high-cost sources, such as chemical plants.[18]

Other data, developed by Liang et al., also indicate considerable heterogeneity of marginal abatement costs across different industries and technologies.[19] Overall, Liang et al. estimate that the costs of abatement range from 600 to 2,000 RMB per ton, with an average cost of about 1,090 RMB per ton of SO_2.

Site visits and interviews in Taiyuan conducted by the RFF team in March 2001 and updated in May 2002 indicated considerable heterogeneity of marginal abatement costs in the city. Table 3.2 summarizes the results of these site visits and interviews for several technologies and industry combinations. More detailed information is presented below.

Option 1. Wet Method

The Taiyuan District Heating Company passes postcombustion gases through calcium carbonate ($CaCO_3$) and sodium hydroxide (NaOH). This process reduces SO_2 emissions by 403 tons per year at a cost of 500 RMB per ton, according to plant officials.

TABLE 3.2

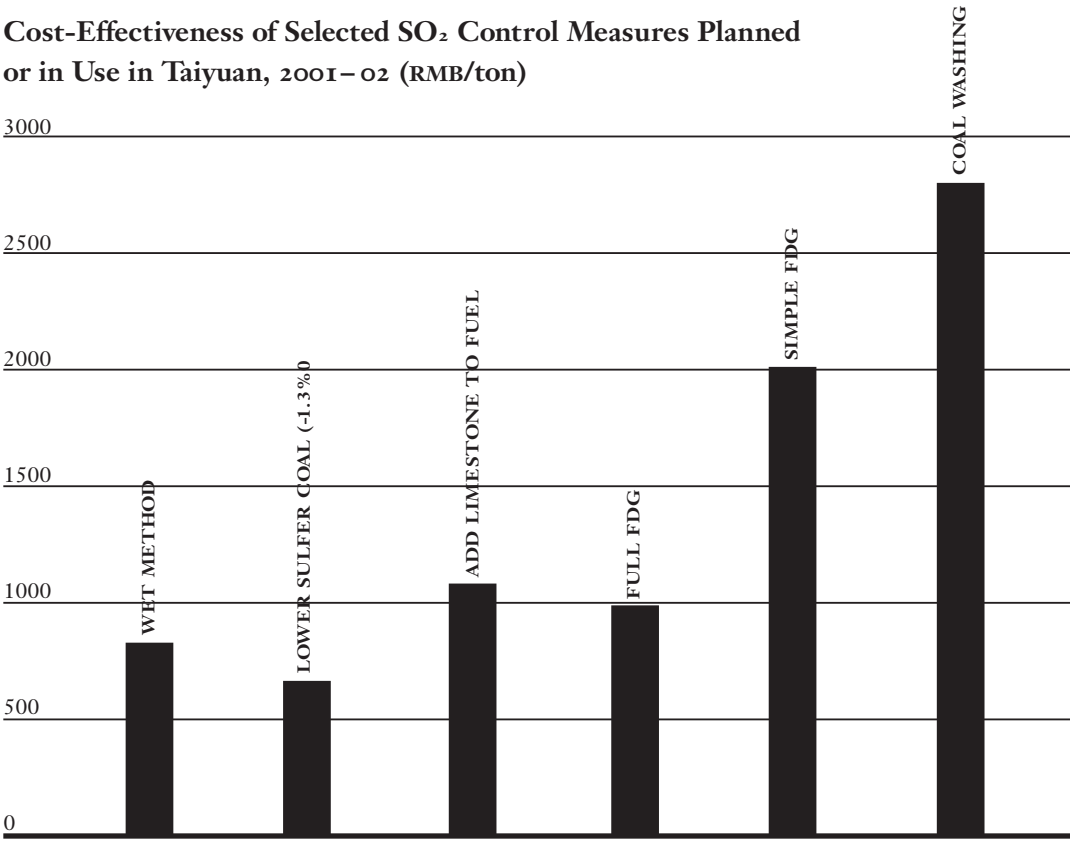
SO_2 Control Measures Planned or in Use in Taiyuan, 2001–02

Control Measure	Status	Where Applied	Cost-Effectiveness (RMB/ton)
Close small boilers	Done	Citywide	Unknown
Wet method	In use	Taiyuan District Heating, Xishan thermal plant, Jinxi	500–1,100 ($60–130)*
Lower-sulfur coal (~1.3%)	In use	Taiyuan Power Plants 1 and 2, Taiyuan Iron & Steel, others	667 ($85)
Add limestone to fuel	Planned	Coal gasification power plant	1,070 ($130)
Full FGD	Planned	Taiyuan Power Plants 1 and 2	1,300–1,667 ($150–200)*
Simple FGD	In use	Taiyuan Power Plant 1	2,000 ($240)**
Coal washing	Limited use	Coking plants	2,800 ($340)

* as estimated by plant officials. ** plus unspecified investment costs.

FIGURE 3.3

Cost-Effectiveness of Selected SO_2 Control Measures Planned or in Use in Taiyuan, 2001–02 (RMB/ton)



Source: Table 3.2. For data originally presented in ranges, the midpoints are used in the graph.

A coal stone power plant, which utilizes waste coal from a coal washing facility owned by the Xishan Coal and Electricity Group, commenced operations in 1995. The coal stone has relatively high sulfur content (over 2%) and ordinarily would not be allowed to be burned, but it receives exemptions because the plant is using a waste product. This plant produces steam for heating needs and is part of the larger Xishan Group (which has approximately 95 boilers). The power plant has three 35-ton boilers. Two are used for primary production and one boiler is used as a backup. Last year the power plant installed "wet method" control equipment, in which $CaCO_3$ and NaOH are introduced into the stack gas primarily for dust control. The facility operator reports 50% to 60% SO_2 removal, for a total of about 2,500 tons of SO_2 per year. Waste from the dust and SO_2 control is used to make bricks. The investment cost for the project was reported to be 1,600,000 RMB, and the operating cost for SO2 removal is approximately 500,000 RMB per year. Since one investment removes both particulates and SO_2, costs are allocated over the sum of tons removed for both pollutants. The implied cost-effectiveness for SO_2 control is 260 RMB per ton. The same technology applied at other enterprises has a cost-effectiveness of 600 to 700 RMB per ton; however, this facility is receiving income from the manufacture of bricks.

The Jinxi Machinery Plant uses the simple wet method. Investment costs for sulfur controls at the four boilers in the residential area were about 430,000 RMB, all of which was financed by the enterprise. For the three boilers in the product area, investment costs were 660,000 RMB: 360,000 RMB came from the return of pollution levy payments and 300,000 from the enterprise. Operation costs for the sulfur controls are about 600,000 to 700,000 RMB annually, plus unspecified (presumably lesser) amounts for staff. This equates to a cost per ton of about 1,100 RMB.

Option 2. Reducing the Sulfur Content of Coal

In the late 1990s, the national government ordered all coal-fired power plants to reduce the sulfur content of coal to a range of 1% to 1.5%.[20] Taiyuan Power Plants 1 and 2 were using coal with an average sulfur content of approximately 2%. By 2000, Taiyuan Power Plant 1 averaged about 1.14% sulfur content, whereas Taiyuan Power Plant 2 reported an average sulfur content of about 1.07%. Coal with a sulfur content of 2% sells for about 90 RMB per ton, and coal with 1% to 1.5% sulfur sells for about 100 RMB per ton. Assuming that 80% of the sulfur in the fuel would be emitted as SO_2 and noting the molecular weight of SO_2 is twice the atomic weight of sulfur, the cost of removing SO_2 by using lower sulfur coal is approximately 830 RMB per ton or 10 RMB / (7.5 kg S × 80% × 2) = .83 RMB per kg.

Option 3. Add Limestone to Fuel

The Taiyuan Coal Gasification Company washes raw coal to obtain low-sulfur coal for its coke and coal gas facility. Waste coal residues from coal washing (*gangue*) are burned at an adjacent power plant. At present, the power plant emits more than 2,000 tons of SO_2 annually. The company is considering mixing limestone with coal gangue before it is combusted, at an estimated annual cost of 750,000 RMB. Although the supplier of this technology says it can achieve a 50% reduction in SO_2 emissions, in experimental trials, the company has achieved a SO_2 reduction of 30% to 40%. Assuming an average removal rate of 35%, the cost-effectiveness would be 1,070 RMB per ton, or 750,000 RMB / (2,000 tons × 35%) = 1,070 RMB per ton.

Option 4. Flue Gas Desulfurization

Taiyuan Power Plant 1 has an SO_2 FGD control project under way at one of its 220-ton boilers. The capital cost of the project is 25.1 million RMB, of which 18 million RMB is from return of levy funds and the remainder is a commercial bank loan. Operating cost will be 5 million RMB per year, calculated to include depreciation and capital recovery. This unit will remove about 3,000 tons of SO_2 per year (a cost-effectiveness of 1,667 RMB per ton).

For the existing boilers in Taiyuan Power Plant 2, the FGD on one 220-ton boiler has been in operation for several years; the other two 220-ton boilers were switched to low-sulfur coal and the sulfur-lowering materials were added at the same time. FGD is to be installed on two 670-ton boilers in 2004. For the new boilers, one 670-ton boiler was installed with FGD. The investment cost will be 19.84 million RMB, all from return of levy payments from the provincial environmental protection bureau. The projected SO_2 removal efficiency is 80%. Last year, emissions of SO_2 totaled 35,000 tons. The investment will reduce emissions by 3,275 tons of SO_2 per year (assuming average sulfur content of 1.5%). Operating costs are projected at 4.72 million RMB per year (including investment recovery). This equates to a cost-effectiveness of about 1,300 RMB per ton (after crediting the lower cost of higher-sulfur coal the power plant intends to use).

Option 5. Simplified FGD

With assistance from the Japanese government in 1992, a simplified flue gas desulfurization unit was installed at one 300-MW generating station of Taiyuan Power Plant 1. To avoid power loss, only two-thirds of the gas is treated. The FGD unit achieves an 80% to 85% reduction in SO_2 content of the treated gas. The FGD unit was a gift from the Japanese, so it had a zero investment cost to the PRC. Annual operating costs for removing 8,500 tons of SO_2 are 17 million RMB, or 2,000 RMB per ton.

Option 6. Coal Washing

Washing can reduce the sulfur content of coal by varying amounts, depending upon the proportions of organic and inorganic sulfur. Washing is quite effective in removing inorganic sulfur and generally ineffective in removing organic sulfur. For coals in Shanxi Province, it is reasonable to assume that washing can reduce the sulfur content by 45%. If coal with 1% to 1.2% sulfur were washed, its average sulfur content would fall to 0.6%. Washed coal is mandated for the manufacture of coke and currently sells for about 120 RMB per ton, versus 100 RMB per ton for unwashed coal containing 1% to 1.1% sulfur. The cost-effectiveness of coal washing is approximately 2,800 RMB per ton of SO_2 or 20 RMB / (4.5 kg S × 80% × 2) = 2,800 RMB per kg.

Overall, based on the national data as well as the information gathered in our site visits, there appears to be substantial variation in marginal abatement costs for SO2 across sectors and among enterprises in Taiyuan. This suggests a solid basis for adopting an emissions trading system.[21]

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CHAPTER FOUR

Design of a Cap-and-Trade System for SO_2 Control in Taiyuan

Although the rationale for a cap-and-trade system to reduce the costs of meeting SO_2 emissions goals is compelling, "the devil is in the details." For such an emissions trading program to be successful, certain policy and administrative issues must be sorted out. The policy issues involve governmental decisions about such matters as the level of overall pollution reduction to be achieved, the deadline for meeting the goal, the actual sources of emissions to be included in the program, the initial permit allocation plan, and the creation of proper incentives for compliance. Administrative elements include compliance, monitoring, enforcement, and reporting systems, each of which also includes policy aspects. Table 4.1 contains a summary of major design elements. It is based on a similar classification system developed by the U.S. Environmental Protection Agency. (An expanded design issue list, along with specific options and related information, is presented as Appendix 6.) This chapter explores the design issues relevant to the Taiyuan demonstration and presents the rationale for the selected designs.

Policy Design

Environmental Goal and Deadline

The Shanxi provincial government decided to cap SO_2 emissions for Taiyuan at 200,000 tons for 2005, representing a reduction of 22.5% from 2000 emissions of 258,000 tons. In the Tenth Five-Year Plan for Taiyuan's economic development, the Taiyuan City government, in consultation with provincial officials, adopted an even more ambitious goal—125,100 tons for 2005, which represents a 50% reduction from the 2000 emissions level. As noted previously, the Taiyuan area had yearly averaged monitored concentrations of SO_2 of 0.20 mg/m^3 in 2000, which is about 230% above the PRC Class II SO_2 concentration standard of 0.06 mg/m^3. No air quality modeling was performed as a basis for establishing the proposed SO_2 cap. However, as a point of reference and assuming reductions in SO_2 concentrations would be proportional to emissions reductions, with a baseline emissions rate of 258,000 tons per year, aggregate emissions would need to fall to about 78,000 tons per year for the standard to be met.

Type of Emissions

Taiyuan has decided to count only stack emissions in its emissions inventories. However, fugitive emissions (that is, emissions from other parts of the plant in addition to the stacks) can be

TABLE 4.1

Summary of Major Design Elements

Policy-Level Design Elements	
Environmental goals	
Emissions level for cap	Maximum emissions limit or cap for the trading program.
Timing (beginning year, target year, and phase-in)	Timing of emissions reduction requirements.
Capturing environmental impacts from emissions trading	Environmental implications to using emissions trading.
Scope and applicability of trading program	
Affected sources	Source categories to be included in the trading program.
Trading area	Geographic scope or area that the trading program covers.
New sources	Incorporating new sources.
Allowance distribution versus auction or sale	
Method sources use to obtain allowances	Different ways for sources to obtain allowances.
Prices	The prices of the allowances.
Relationship with discharge standards	Will the emissions trading system interfere with other discharge standards?
Banking	Will sources be allowed to save allowances for use in future compliance years?
Administrative Design Elements	
Emissions quantification, reporting, and verification	
Emissions quantification	Standards for emissions measurement.
Emissions reporting	Reporting standards for emissions data.
Verification	Validating emissions data, including quality-control checks of methods used and equipment (monitors).
Allocations	
Defining and allocating allowances	Define allowance. Establish an allowance distribution method. Allowance accounts. Who can hold allowances.
Legal authority and responsibility	
Authority and roles	Program administration. Legal framework (within which emissions trading laws could be developed).
Compliance	Procedure for compliance determination. Authority to enforce noncompliance at the source level. Noncompliance penalty. Trading program interface with levy system.
Information systems	
Tracking systems	Emissions tracking. Allowance tracking. Allowance transfers.

a very large fraction of total emissions for coke plants, iron-and-steel plants, and other heavy industrial sources, and they were visible during our inspections of various facilities in Taiyuan. Counting them in the cap would likely have environmental benefits and result in the setting of a more realistic and comprehensive cap. On the other hand, it is difficult to estimate fugitive emissions, and it was decided that this challenge should be left for future modifications to the program.

Start Date

When a new program actually begins implementation depends on the extent of the commitment to the specific date established in the Tenth Five-Year Plan (2005), the politics of developing the consensus and legal framework to move forward, and various implementation issues, such as agreements reached between all affected parties about when the program can take effect. As stipulated in the Administrative Regulation on SO_2 Emissions Trading Program in Taiyuan, the program will be in effect 30 days after the regulation is issued. It was issued on October 6, 2002. Thus, technically speaking, the program is already in effect now.

Temporal and Spatial Complexities

In discussions, the RFF team and the Taiyuan Environmental Protection Bureau (TEPB) considered the problem of accounting for the greater health effect of emissions in winter than in summer and for the greater population exposure caused by some sources because of their geographic location. Further, initial model simulations suggest some potential for emissions trading to have (somewhat) disproportionate air quality impacts in different zones in Taiyuan, depending on the nature (and direction) of the trades (see Appendix 7 for details). However, in the interest of simplicity, the final design made no distinction as to when or where the emissions occurred. As the system becomes fully operational, it would be appropriate to examine this issue further, with the possibility of revising the trading rules if warranted.

Scope of SO_2 Emissions Trading Program

A crucial decision is which sources of SO_2 emissions are to be involved in the trading program. Options include all sources, large industrial and other point sources, only the largest sources, and already-permitted point sources. TEPB decided that the 23 coal combustion sources that had been given emissions quotas or targets for 2001 would be included in the proposed trading program. Although there are other large sources of SO_2 emissions — such as a glass company and some other users of sulfuric acid (H_2SO_4) — TEPB recommended initially limiting trading to combustion sources. Emissions from the 23 enterprises proposed for the demonstration account for approximately 50% of the total SO_2 inventory in Taiyuan (not counting fugitive emissions). These sources are also regarded as having relatively strong management. TEPB has allocated SO_2 quotas (sometimes referred to as permits for smoke dust and SO_2) to these sources, and there are estimated emissions for each source.

Geographic Scope of Trading Area

The decision on the geographic scope of the trading area largely follows from the decision on which sources would be covered. TEPB decided to include just the city proper. Including the au-

tonomous municipality of Gujiao as a part of the Taiyuan SO_2 control zone was considered but rejected, as it would require another level of administrative coordination.

Initial Allocation of SO_2 Permits

How these allowances are distributed is often the most controversial element of a trading program because the allowance represents a valuable economic asset to an enterprise. Allowances were given away in U.S. programs, but recent research suggests that they should be at least partly auctioned.[22] Alternatively, they could be sold at a predetermined price, although this method would not be as efficient and would invite resistance from the firms. The options imply different degrees of administrative complexity. In general, if the permits are given away, the receiving enterprises may reap benefits upon selling their permits. In contrast, if the permits are sold, the revenues generated can be used by the government.

Most government officials felt that the sale of emissions quotas at fixed prices or through an auction probably would not be a feasible allocation mechanism at this time. They noted that sources have limited financial resources because of depressed economic conditions and low profit margins. Some officials focused on the possibility of allocating most emissions allowances to sources in proportion to historical quotas but reserving 10% to 15% of the allocation for new growth.

Based on extensive discussions and analyses among the RFF team and local officials, the following principles were established:

- In general, the 2005 SO_2 reduction goal for each source is 50% of its 2000 reported SO_2 emissions. A uniform annual reduction (equal amount) is to be applied to each source from 2001 to 2005.
- If participating enterprises are the SO_2 control point sources in Taiyuan's Tenth Five-Year Plan and their 2005 SO_2 emissions specified in the plan are already lower than 50% of their 2000 reported emissions, their planned 2005 SO_2 reduction goals are used.
- If sources are listed in the 2001 environmental responsibility contract system, their 2001 contract emissions are adopted as the baseline. A uniform annual reduction (equal amount) is applied to each source from 2002 to 2005.
- If sources' SO_2 emissions specified in their 2001 environmental responsibility contracts are already lower than 50% of their 2000 reported emissions, their 2005 reduction goals are set at 20% below 2001 permitted emissions. Each is required to reduce 5% of its 2001-permitted SO_2 emissions every year, starting from 2002.

The final allocations established by TEPB for the 23 enterprises are shown in Appendix 8 (fugitive emissions are not included in these allocations).

Pricing Allowances

Once the allocations are made and the program begins, a market for emissions permits may develop. In a free-market system, the price of a ton of SO_2 emissions will quickly become established, and under appropriate administrative structures and information systems, it will be widely known by all market participants. Alternatively, the price of a permit may be set administratively by, for example, TEPB or by the Price Bureau, an approach considered by Taiyuan officials.

A major problem with fixing the price of emissions permits is that the quantity is also fixed. With both price and quantity fixed, it is likely that there would be either excess demand for the quotas or excess supply.

Relationship with Discharge Standards

An important feature of emissions trading is that sources are permitted to buy or sell allowances without limit. But what does that imply for sources facing specific emissions standards? In fact, the language in the existing Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City[23] (Item 19) is unclear on this point. It states that permits are tradable so long as the discharge standards are met and the trading is "supervised" and "instructed" by TEPB. If the standards cover stack concentrations, this provision contradicts the essence of emissions trading. If they are mass-based standards, it may not be a problem. The concentration-based standard obviously affects public health, while the mass-based standard is the TEC parameter. It is possible for the concentration-based standard to be met while the mass based standard is "exceeded" using a purchased allowance. Further clarification from TEPB is needed on this matter.

Banking

Another major policy decision is whether sources can "bank," or save, unused allowances for future use or sale. Banking can provide firms needed flexibility in developing control strategies. In the United States, banking has taken place without environmental detriment. Indeed, experience has shown that a significant number of tons tend to be banked each year, resulting in fewer emissions than allowed by the cap and correspondingly better environmental quality. Such emissions may be used in the future, worsening environmental quality over what it might have been otherwise, but this possibility is likely to be balanced by the fact that environmental improvements occur sooner. Experience also shows that some emissions will always be in the bank as insurance against future need, which tends to generate additional environmental improvements.

Item 20 of the Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City allows banking as long as prior approval is obtained from TEPB. In various discussions, TEPB and company representatives suggested that banking would be a useful feature for a full-scale trading program but not necessarily in a one-year demonstration. However, at a major meeting of all stakeholders on this issue, it was decided to include a banking provision in the demonstration program to add a degree of flexibility in the timing of emissions reductions. As noted in the recommendations (Chapter Six), the RFF team is suggesting that the requirement for prior approval by TEPB be removed from the regulation.

Emissions Set-aside

U.S. EPA withheld part of the allowances issued for the SO_2 trading program. Some of these allowances were sold at auctions to ensure a supply for new emissions sources, and others were given away to reward desired behavior (such as investing in renewable energy). It was agreed that a small set-aside of allowances would be held by TEPB.

Administrative Design

Parallel to handling the policy design issues, a wide range of administrative design issues were considered. The administrative elements cover important details of the trading system, including compliance, monitoring, enforcement, reporting elements, legal issues, and information systems. Many of these decisions are needed for any emissions-based regulatory system to function properly, not only an emissions trading system.

Emissions Quantification, Reporting, and Verification

It is beyond dispute that regulators and the public must be assured that real, not imaginary, pollution reductions are being traded. Thus, tight procedures for determining the quantity of emissions actually emitted are essential. The best approach is to install continuous emissions monitors (CEMs) in the stack. Indeed, some major sources in Taiyuan already use CEMs to track their emissions, but these devices are used either by the plant for internal purposes or intermittently by TEPB inspectors in their periodic inspections. Standards need to be applied to ensure that CEMs are installed and operated properly and calibrated regularly.[24]

Another improvement would be to ensure that the information obtained from monitoring is easily available to regulators. A central database for CEM data is under development by TEPB and was scheduled for use in 2003. It includes on-line data transfer using the Internet. Alternative techniques involving direct or indirect measurement of fuel use and sulfur content are available. However, the accuracy of estimations depends on certain assumptions—that control equipment is functioning properly and has been turned on, for example. Inspectors also need some level of assurance about the source of the fuel—not a trivial issue in countries with limited data collection and verification histories. At a meeting of TEPB staff and the regulated companies, participants suggested that the bureau's current estimation method be accepted in lieu of CEMs during the demonstration phase. Regulated companies also expressed an opinion that calculations based on fuel use and sulfur content could be more reliable than quarterly monitoring from TEPB.

Legal Authority

In a law-based society, laws represent a commitment by society to address specific problems in an agreed-upon manner. Although the PRC is not historically a law-based society, in recent years, it has seen a proliferation of laws, including the legal framework under which the emissions trading program would operate—TEPB's Permits Exchange Regulation, issued as part of the Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City in 1998.

Personal responsibility has generally been a more important motivator in the PRC than law. Under the Environmental Responsibility System (*huanjing mubiao zeren zhi*), local officials such as provincial governors, city mayors, county magistrates, and managers of enterprises assume responsibility for environmental quality through written contracts or agreements. These agreements specify environmental targets in their respective jurisdictions for a particular time period.[25]

Administering the Program

One government institution needs to take primary responsibility for the administration of the program. The obvious institution to do this is TEPB, because it is responsible for emissions regulation and already has in place the beginnings of the necessary monitoring and enforcement in-

frastructure. The role for the provincial EPB and the relationship between the provincial EPB and TEPB still needs to be worked out. In particular, because power plants are regulated from a provincial (and even national) level, procedures and regulations need to be developed for addressing power plant regulation within the local permits exchange system. One can also envision a role for enterprises and perhaps other institutions in building and maintaining support for this program. In particular, the provincial and local planning commissions should play a supportive role.

Compliance

No environmental regulatory program works without a system to ensure compliance. A strong compliance program has many aspects, all of which are designed to ensure that sources will play by the rules and that the rules will be fair, clear, and consistently applied. We list several technical programs put into place to manage disputes and disagreements and to make sure enterprises are following the rules. The enforcement issues are discussed in a separate section below.

- *Emissions tracking system (ETS).* TEPB needs information to determine whether enterprises are operating within the parameters of the system, including whether their SO_2 emissions are less than or equal to the allowances they hold. The ETS was developed to integrate technical monitoring information collected by TEPB with additional data on coal purchases, new SO_2 control measures undertaken, enterprise-level output, and other factors. Enterprises will be able to submit their data in electronic (or paper) format, and TEPB will be able to generate reports specifically tailored to its regulatory needs. (See Chapter Five for a detailed description of the ETS.)
- *Allowance tracking system (ATS).* By reporting and verifying trades, this program will ensure the functioning of the trading system. (See Chapter Five for a detailed description of the ATS.)
- *Provision for reconciliation.* In the process of buying and selling allowances, the enterprises will normally need to reconcile their emissions and permit holdings. Thus, they may need to buy additional allowances to be sure that their emissions do not exceed the allowances held. Procedures for reconciliation were written into a guidebook as part of the project. (See Chapter Five for a detailed description of the Procedures Guide.)
- *Appeals process.* Disputes will arise in any process, particularly a novel one like emissions trading. To resolve disputes, it is proposed that a mediation committee be established (see page 50). The committee could consist of senior government officials and enterprise managers, plus perhaps members of the academic community, the public, and the media.

Noncompliance Penalty

To ensure that enterprises involved in emissions trading follow the rules, the "cost" of violating an emissions limit must be higher than the "benefit" to the violator. Penalties could be financial, such as a fee on each unit of emissions exceeding the allowances held, or other kinds of disincentives, such as public disclosure and criminal prosecution of violators. One option is to make the compliance penalty at least as high as the cost of coal washing. Currently, coal washing costs about 9,600 RMB per ton of SO_2. Setting the penalty at a slightly higher level than the cost of

coal washing would ensure that compliance is less costly than paying the penalty for emissions in excess of one's quota.

At a major stakeholders' meeting on the program, participants recognized that penalties for noncompliance should be higher than the marginal cost of compliance, but they also suggested that the penalties be set at "realistic" levels. The Administrative Regulation on SO_2 Emissions Trading in Taiyuan City limits penalties to 30,000 RMB per year, which is likely too small to induce full compliance with the program.[26]

Levy System and Integration with Trading System

The need for a penalty system raises the larger issue of the interface between the existing pollution levy system and the penalty system, as well as that between the pollution levy system and the emissions trading system.

Levies are paid on every unit of SO_2 emissions, whether these emissions exceed the enterprise's quotas or not. However, these levies are currently too low relative to the cost of reducing SO_2 emissions to significantly discourage emissions. Also, our understanding is that most of the levies are returned to the enterprises paying them in order to finance new pollution control investments, with the rest retained by the EPBs.[27]

Options for integrating the two systems include (1) recognizing that the levies are very low and allowing the two systems to coexist; (2) eliminating the levy on SO_2 to all participating enterprises but auctioning or selling SO_2 emissions allowances at an administered price and relying on penalty collections to pay TEPB expenses; and (3) giving allowances away but imposing a small surcharge equal to the levy (very similar to the first option). It is not possible, however, to discontinue the levy without prior approval from the State Environmental Protection Administration (SEPA). Technically, a system in which a levy is high enough to change polluting behavior duplicates a trading system. At any one time, either the price of a unit of emissions set in the market or the levy rate will be binding. A small levy that is used for raising revenue, such as now exists, presents no obstacle to the successful functioning of an emissions trading system.

Mediation Committee

Inevitably, there will be disputes among participants in a trading system. In the RECLAIM system in California, for example, a broker was found to be selling fake or invalid credits. Transparency can play a role in ensuring a fair emissions trading system, as discussed below. Courts are also a means for ensuring fairness and settling disputes. Neither transparency in public administration nor a strong independent judiciary currently exists in the PRC, however.

One way to increase trust and transparency and help compensate for the absence of an independent court system would be to establish a project mediation committee for the resolution of potential disputes among parties to a trading regime. The committee could consist of senior governmental officials, such as the vice governor, deputy mayor, environmental officials, and representatives of relevant government institutions, including the planning commission, plus representatives from industry and possibly academia, the media, and the public. Based on U.S. experience, the committee would need to function in a relatively transparent manner—issuing written decisions or hearing disputes in relatively open sessions—to be perceived as fair. No action has yet been taken on this suggestion.

Transparency and Public Information

In the United States, decisions about allowance allocations, information on actual trades, and virtually the entire program are subject to public inspection. This helps ensure that there is no cheating, that everyone is treated fairly, and that interest groups (including neighborhood groups, nongovernmental organizations, and competitors) have confidence in the program. By its very nature, any environmental management system, including emissions trading, allows different enterprises to emit different levels of pollution. Among those who are not fully knowledgeable about the program, this can create misunderstandings about whether firms are being treated fairly and equitably. In addition, the public and the regulated community must have confidence that trades are legitimate, that the grant of discretion to a particular plant is not based on favoritism, and that the program does not enrich plant owners or operators, regulators, or other vested interests at the expense of the environment. A campaign to inform the public about the program may reduce suspicions that the program has been instituted to benefit favored units, enterprises, or individuals or to punish others. Transparency can also promote enforcement if, for example, a disclosure system is established so that an informed public can, in effect, help keep the program honest.

Public disclosure would be consistent with the current Chinese emphasis on increasing environmental awareness. Article 15 of the new Air Act has provisions calling for greater transparency in the setting of the TEC and the issuance of emissions permits. The World Bank, with the assistance of the Chinese Research Academy of Environmental Sciences (CRAES), is working on a disclosure system for the PRC, using color coding and public disclosure as a means for channeling public pressure for environmental compliance. A form of public disclosure is already being used in many cities, where an ambient air quality index is being made available to the public on a "real-time" basis. Moreover, the Chinese media have increasingly been used to pressure polluting units to control their emissions, through public disclosure. Many large cities have "green" newspapers and broadcast reporters. In 2003 TEPB reported in the local newspaper on the efforts that sources were making to reduce emissions. In 2004 the bureau plans to prepare a report for the government and for enterprises that discusses emissions and facility utilization.

Additional Issues

Over the course of this project, stakeholders, including local officials and enterprise representatives, raised certain issues about emissions trading that have not been covered in previous sections—specifically, (1) concerns that emissions trading might not be feasible because of the high percentage of emissions emitted by a relatively small number of sources; (2) concerns that poor economic conditions could hinder trading; and (3) concerns that a stronger demonstration of high-level government support will be necessary before emissions trading can proceed. We consider each of these issues in turn.

1. **A few large sources and many small sources might present significant challenges to an emissions trading system.** Taiyuan has two very large sources and a few other sources with substantial emissions. The remaining sources, though numerous, are relatively small. Participants feared that the size distribution of the sources might create a problem for emissions trading. Our response is that the emissions market could possibly be distorted by monopolies of one or two large firms. We suggested that the Taiyuan authorities monitor trades closely to see if such

behavior is evidenced. Size alone, however, is not the major factor in market distortion. Rather, the crucial measure is the difference between the number of allowances granted to a source and its current emissions. This difference need not be greater for large sources than for small sources. A skewed size distribution exists in Los Angeles but monopoly behavior has not been an issue in the RECLAIM program, where a few power plants dominate in quantity of emissions. The fact that TEPB intends to hold some reserve permits also gives it some leverage against monopoly practices.

2. Poor economic conditions within the firms might lead to resistance to emissions trading. Concern was expressed at the workshops about the economic health of the Taiyuan enterprises and whether this would affect their ability to participate in an emissions trading program. A successful emissions trading program begins with clear regulatory goals for reducing emissions. The environmental authorities in Taiyuan and Shanxi Province must make it absolutely clear to sources that they will, in the aggregate, need to reduce emissions by specified amounts. If because of their shaky financial condition, sources are not in fact required to meet the requirements and the regulation is not truly enforced, then neither emissions trading nor any other approach will succeed. However, a trading system with genuine requirements can reduce compliance costs below those that would be incurred if all sources were required to meet the same reduction goals in the same time frame. Thus, firms might be expected to support the trading program to the extent that the government is serious about reducing emissions.

3. For emissions trading to succeed in Taiyuan, a stronger demonstration of high-level government support for emissions trading is needed. Several workshop participants made the point that no emissions trading program can succeed in Taiyuan without explicit support from high levels of the city and provincial governments. We have suggested that the Shanxi Planning Commission convene an advisory group of senior government officials and industry managers in Taiyuan to assess the overall demonstration and a working group of technical staff to monitor the its detailed operations.

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CHAPTER FIVE

Detailed Implementation Decisions

The cap-and-trade program of the Taiyuan Environmental Protection Bureau (TEPB) has the potential to be an effective tool to reduce SO_2 emissions at a lower cost than conventional pollution control programs. This chapter outlines efforts made to strengthen institutions and overall conditions for implementing and operating the cap-and-trade program in Taiyuan. It describes the emissions and allowance tracking systems that were developed to account for emissions, fuel purchases, production, and allowance trading. It also describes procedures for operating and enforcing the program. Further, this chapter outlines the obligations for enterprises participating in the program, including the procedural steps that they must undertake. Finally, it describes a simulated trading exercise that took place in Taiyuan in December 2002 and identifies additional capacity-building needs. The full details of the implementation issues are contained in a procedural guidance produced by the RFF team (Appendix 9). Included in the procedural guidance are also a series of annexes that explain the documentation work following the step-by-step guidance.

The Emissions Tracking System

An effective emissions trading program requires the regulatory authority to collect sufficient data to track and verify emissions from all units at each participating enterprise. In the course of the project, the RFF team developed an emissions tracking system (ETS).[28] This computerized data system collects, verifies, and maintains data about mass emissions, fuel purchases, and production at the enterprises participating in the emissions trading program. The ETS uses fuel consumption and output data to directly estimate emissions. The principal advantage of the ETS is that it provides a validation check on the other emissions estimation methods in use.

In the United States, emissions tracking is achieved mostly through the use of continuous emissions monitors (CEMs). In the absence of CEMs, Taiyuan's current system uses a variety of methods to determine compliance with total emissions limits and calculate the pollution levy. The alternative methods yield results that can vary widely, leading to different interpretations of what the emissions from a source are. CEMs are now being installed at many of the larger Taiyuan emissions sources, but for the foreseeable future, many enterprises will need to rely on alternative means.

The ETS has been designed to help TEPB estimate emissions from those sources that do not use CEMs. In addition, it will maintain measurements from TEPB's periodic stack tests and from CEMs, when they are installed.

TEPB appears to have the technical and staff capacity to implement the ETS. It has adequate computer facilities to run the software and staff who are familiar with Microsoft Access, the platform on which the ETS was developed.

Enterprises will use the ETS system to enter information about monthly changes in fuel inventories (such as beginning fuel inventory, fuel sales, fuel purchases, and fuel consumption), characteristics of fuel (such as sulfur content), production levels (such as quantity of electricity produced), and measured emissions at each boiler, if available. At the end of each quarter, enterprises are expected to export all the data to a file on floppy disk and submit the disk to TEPB.

At the end of the reporting period, TEPB will import the submitted reports and manually enter the data for enterprises that do not have access to computers. In addition, when TEPB's monitoring bureau itself inspects an enterprise, staff are expected to enter the monitoring data, including emissions concentration and emissions flow, into the ETS.

When the emissions data and other supporting information are entered into the ETS, the software automatically looks for missing information or inconsistencies with previous reports by the enterprise (for example, if the enterprise emitted four tons of SO_2 per unit of production in one month and only one ton per unit the next). After all information is imported or entered by TEPB, staff can use the ETS to create a report that identifies all boilers and enterprises with missing data, inconsistencies, or no reported emissions.

Box 5.1 shows an exhibit of the user interface of the emissions tracking system.

The Allowance Tracking System

The RFF team also developed an allowance tracking system (ATS). The ATS is the emissions trading accounting system, recording data on SO_2 allowance holdings and transfers. Taiyuan's system is computerized to collect, manage, analyze, and disseminate allowance data. Using ETS emissions data, the ATS is a convenient and automated means of determining compliance with the emissions trading system.

The Taiyuan system is loosely based on the system used in the U.S. Acid Rain Program since 1994 to account for allowance allocations, transfers, and surrenders. However, there is one significant difference. The U.S. system is available to the public on the Internet. The U.S. Environmental Protection Agency (EPA) has said its system is "unprecedented in its accuracy and comprehensiveness" in order to ensure system integrity. The Taiyuan ATS resides on a standalone computer in TEPB offices and the information is available, at least so far, only to government authorities.

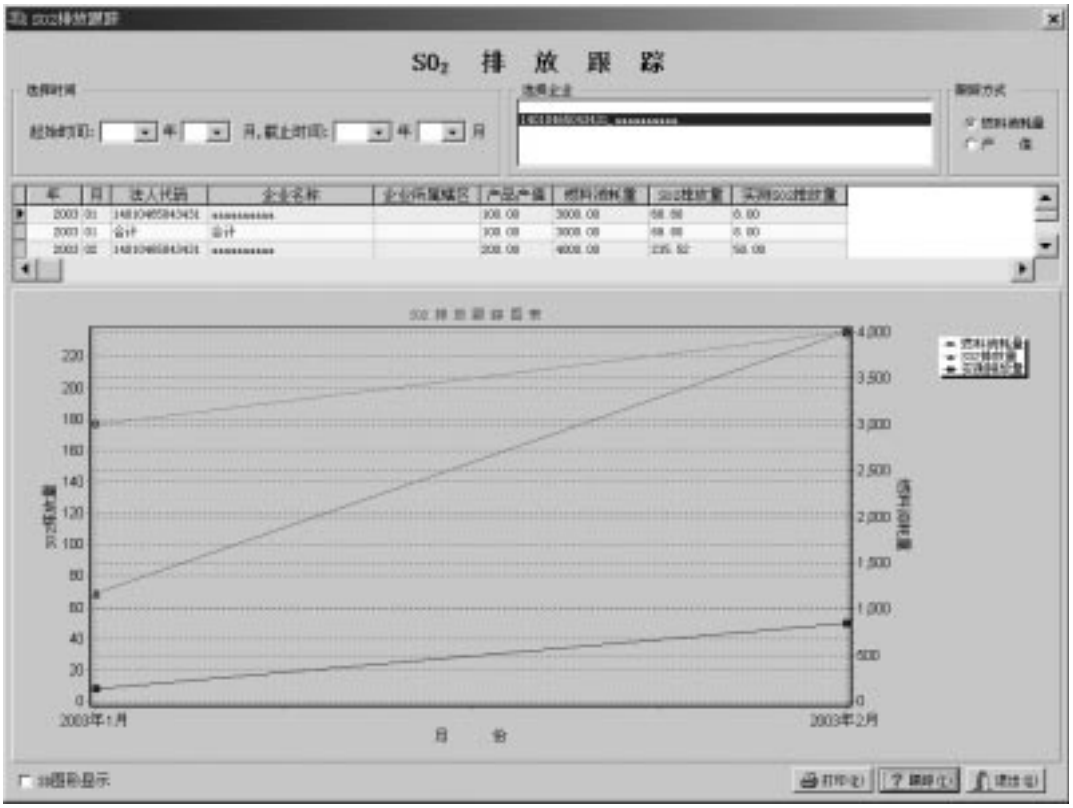
Specific functions of the ATS include the following:

Account Maintenance. TEPB can use the ATS to enter information about the participating enterprises, including name, address, contact person, and whether the enterprise is permitted to transfer allowances. Authorized personnel at TEPB can modify this information to ensure its accuracy.

Issuing Allowances. TEPB can use the ATS to "issue" new allowances to each account. The allowances are issued for a specific compliance year, and once they are in the enterprise's accounts, its account balance is updated.

BOX 5.1

Exhibit of Emissions Tracking System[29]



Transferring Allowances. After TEPB accepts an allowance transfer, authorized personnel can enter the transfer information. The details on each transfer include transferring account, receiving account, vintage or year of allowances, and number of allowances. After the information is entered, the ATS requests a confirmation from the authorized personne to verify that the transaction is correct.

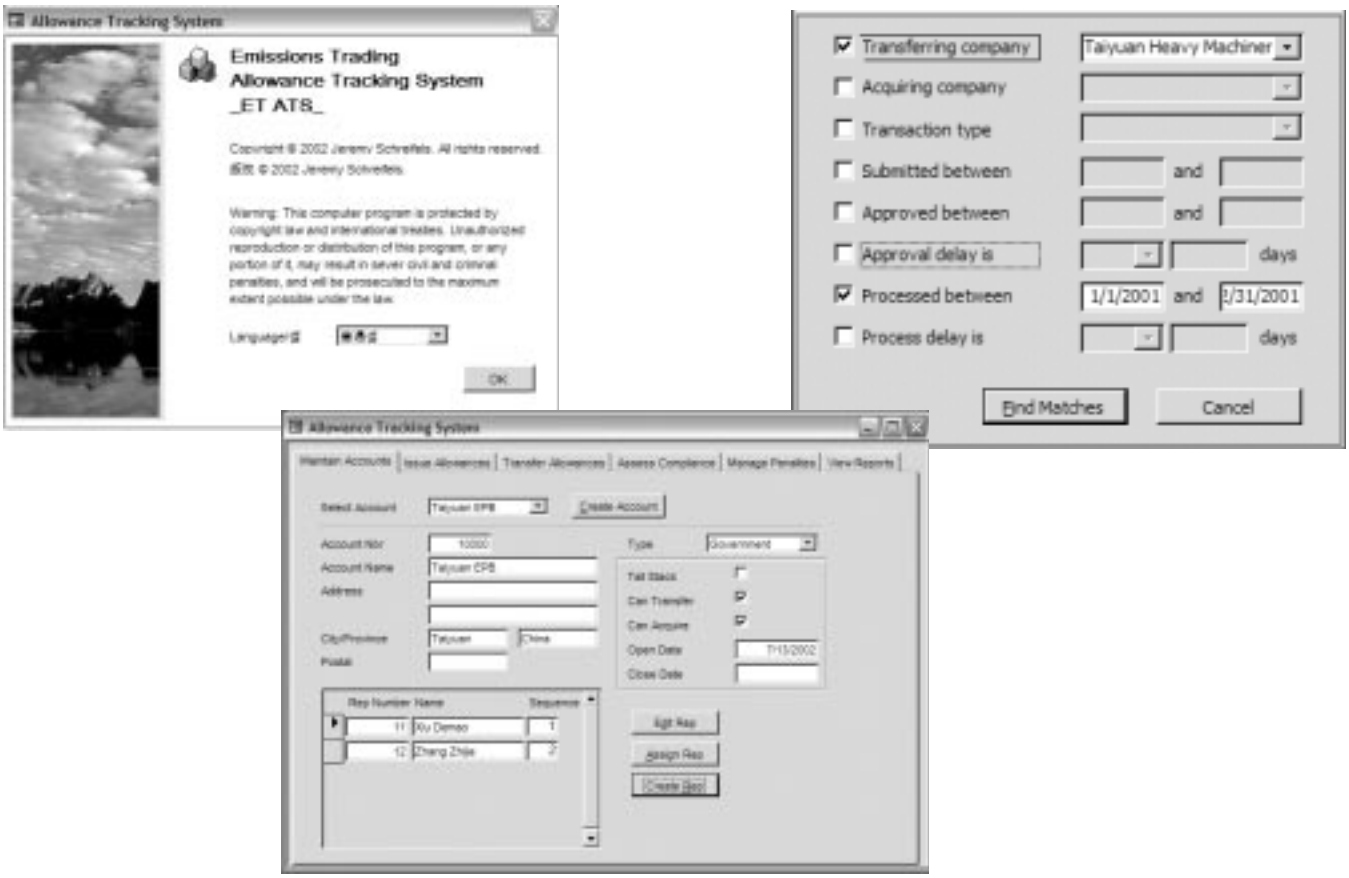
Surrendering Allowances for Compliance. At the end of each compliance period, TEPB can use the ETS to determine the total quantity of SO_2 emitted by each enterprise. The bureau can then transfer this information to the ATS, which will automatically subtract the appropriate number of allowances from each enterprise's account. After reconciling emissions and allowances, TEPB can print a report that lists the enterprises that were not in compliance with the program.

Security. The ATS contains critical information for the operation of the pilot emissions trading program. It is therefore important that the system be secure from unauthorized personnel. The ATS requires users to log on with a user name and password before accessing the system. In addition, a subsequent release of the ATS may provide for different types of access (such as, view-only).

Box 5.2 shows an exhibit of the user interface of the ATS.

BOX 5.2

Exhibit of Allowances Tracking System



There are numerous advantages to using computerized tracking systems, beyond the basic purpose of ensuring system integrity and transparency and building public confidence. A flexible, comprehensive tracking system to collect and manage data on emissions and tradable allowances provides the following benefits:

- *Enhanced access.* Electronic data storage makes it easier and faster to retrieve, analyze, and evaluate relevant data on demand. In the United States, improved access to data promotes confidence in the trading program by permitting program participants and interested members of the public to retrieve data to ascertain compliance, evaluate a program's effectiveness, and make informed decisions. In the same way, data transparency can also facilitate efficient markets, build public acceptance, and foster credibility.
- *Reduced time and costs.* Automated data quality checks reduce the time and costs required to complete, process, and review paper forms. In addition, the electronic storage of data significantly reduces, or even eliminates, the costs associated with the collection, transport, storage, and dissemination of paper forms.
- *Improved consistency and comparability.* Electronic data storage encourages consistency by requiring all program participants to report the same information in a common reporting format. This consistency promotes comparability across time and among program participants.

Program Operations and Enforcement

Sustained institutional commitment is a necessary part of any program for environmental protection. Elements of this commitment range from the analytic to the bureaucratic to the administrative (or legal), and a strong and sustained enforcement program is an integral part. This section reviews the elements and discusses whether and how they have been addressed in Taiyuan. Many elements were in place at the start of the program, others were developed by the RFF team, and still others need additional work.

The discussion includes elements basic to any form of regulation and those specific to emissions trading. For example, enforcement is a necessary part of any environmental regulatory program, but emissions trading programs may require more accurate and complete emissions reporting. In the U.S. SO_2 program, for example, approximately 75% of U.S. EPA staff resources are focused on emissions measurement. In addition, emissions trading programs require administrative resources to manage allowance data and the transfer of allowances. Some requirements follow.

- Administrative and legal institutions must have the legal authority, institutional capability, and culture to enforce environmental regulations. Sources need to be certain that the rules of the program will be applied equally and will not change without a fair process.
- Senior government officials need to be engaged and willing to champion the program from concept to regulation to implementation.
- Historical emissions and air quality data allow administrators to determine the extent of the problem and the sources that contribute to the problem.

- An understanding of the options and costs for reducing emissions is necessary to determine what level of emissions control is economically feasible.
- Enterprises must have access to control technologies or practices to reduce emissions. If the sources cannot purchase, install, transition to, or operate the technologies or practices to reduce emissions, the program will not succeed.

In Taiyuan, many of the functions specific to emissions trading—total emissions measurement (that is, mass emissions as opposed to concentrations), reporting, verification, and allowance accounting—are the responsibility of the staff operating the ETS and ATS. Continual efforts are under way to improve the accuracy and overall quality of emissions data.

Regarding enforcement, the RFF team made suggestions about how officials could improve their operations. Specifically, RFF recommended that TEPB establish clear guidelines for the following enforcement activities:

- A plan for unannounced inspections that, if manpower is sufficient, requires several visits a year to each plant. An inspection program would send a clear message that TEPB expects enterprises to be in compliance and meet their commitments. The plan should include details on what the inspectors are to examine and the collection of supplemental data (such as production) to compare reported and expected emissions.
- Missing data procedures to compensate for incomplete emissions measurement reports. The procedures should be conservative so that they provide the proper incentive for sources to fully report their emissions and supplemental data.
- Clear chain of command for making decisions on enforcement actions. This has two benefits: it makes clear what persons (and in what order) are responsible for making enforcement decisions, and it builds trust by ensuring consistency in the application of laws and rules. For example, if an inspector has a question after an inspection, whom does the inspector contact at TEPB?
- A penalty structure that sets rules so that *de minimis* violations through major noncompliance are accounted for. The Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City and the Administrative Regulation for SO_2 Emissions Trading in Taiyuan City set a range of fines (for example, 3,000 to 8,000 RMB for each excess ton of emissions). There is, however, no explicit explanation of how the actual fine will be determined (that is, when does TEPB assess a penalty of 3,000 RMB per ton versus 8,000 RMB per ton?). In addition, there is no explanation of punishment for minor offenses (for example, submitting incomplete emissions measurement reports). A penalty structure will provide sources with a clear indication of the consequences for noncompliance. In addition, it reduces the discretion of regulators and treats all sources equally. Penalties may be classified as follows:

Administrative. TEPB may resolve the problem by requiring the source to submit or resubmit paperwork, and if the problem is recurring and/or more significant, the bureau may assess a small financial penalty.

Civil. TEPB would assess financial and other penalties for violations.

Criminal. TEPB may pursue criminal penalties against individuals or organizations responsible for egregious violations.

Obligations of Enterprises

The enterprises in Taiyuan City that participate in the SO_2 emissions trading program must meet certain obligations, some of which are not within managers' current experience. The basic obligations will be to measure and report total emissions to TEPB and hold at least one allowance for each ton of SO_2 emitted during the calendar year. Enterprises must also comply with requirements of other applicable environmental regulations, notably the pollution levy.

Since industry in Taiyuan is unaccustomed to functioning in a true market economy, many of the principles involved in emissions trading are relatively new. For example, enterprises and their managers are being asked to engage in transactions that involve exchanging complex and intangible property rights; heretofore their experience has been mostly with a system of "soft budgets" and managed transactions in the context of unitary ownership structures.

Enterprises participating in the emissions trading program must take the following steps:

Select an authorized account representative (AAR) and alternate AAR.

Each enterprise must designate one primary authorized account representative, who will be responsible for transferring allowances, managing the enterprise's allowance account, and certifying all reports for the emissions trading program (including all ETS and ATS reports). The AAR is also the person TEPB will contact with questions about documentation and information about allowance auctions and possible trading partners.

Each enterprise must submit a certificate that identifies a primary AAR and alternate AARs in case the primary AAR is not available. The larger enterprises can readily appoint and train staff for these duties.

Establish an account.

Each enterprise must have an allowance account in the ATS. The purpose of the account is to keep track of SO_2 allowances, including allowances allocated by TEPB, purchased or sold by each enterprise, and banked for future use. After TEPB receives the Account Certificate of Representation form, the bureau will establish an allowance account and assign an account number that the enterprise and AAR must use in all TEPB correspondence and forms.

Hold sufficient allowances to comply with requirements.

Each enterprise must hold allowances equal to or greater than its annual SO_2 emissions. As a starting point, an enterprise's "assumed" reduction obligation is equal to the enterprise's predicted emissions minus its initial allowance allocation. Each enterprise can meet its emissions requirements by using a combination of the allocated allowances, allowances obtained from other market participants, and auctioned allowances, together with any emissions control strategies.

Establish an emissions monitoring and data collection system.

The Administrative Regulation on SO_2 Emissions Trading in Taiyuan City will set a goal for each enterprise in the program to install continuous emissions monitors to monitor its mass SO_2 emissions. Until such monitors are installed and certified, fuel use and other data submitted through the ETS as well as TEPB and self-monitored data will be used to estimate SO_2 emissions.

Enterprises are responsible for the supervision, verification, and reporting of their emissions data, subject to examination and verification by TEPB. In its verification role, the bureau should make unannounced inspections at facilities of participating enterprises, subject their stacks to testing with mobile CEM units or other equipment, and make other inquiries as necessary to meet its enforcement responsibilities.

Report quarterly emissions.

The AAR or alternate AAR must submit reports on the enterprise's self-monitored SO_2 emissions to TEPB, which will verify that the reports have been received.

Initial Emissions Trading Simulation among Selected Facilities

In December 2002, TEPB and the project team tested the emissions trading program by creating a hypothetical compliance year and running the procedures for account creation, allowance allocation, emissions reporting and verification, allowance trading, auction operation, and compliance determination.

In this simulation, TEPB used the ATS to allocate allowances (2003 allocations) to the enterprises. The enterprises used the ETS to submit emissions data to TEPB for verification and then considered their positions and pondered possible trades with the other enterprises. Initially, there was no trading activity because, as the enterprises explained, they would rather pay the 30,000 RMB penalty than go through the process of analyzing their positions and negotiating a trade. In response, the penalty cap was hypothetically lifted for the purposes of the exercise, and the enterprises began to negotiate trades. Taiyuan Power Plant 1 traded 2,130 allowances to Power Plant 2 for 200 RMB per allowance. The price was low because Power Plant 1 viewed its control investments as sunk costs and the allowance price was additional revenue. Dongshen Power Plant and Taiyuan Heavy Machinery negotiated for approximately 20 minutes and arrived at a price of 4,000 RMB per allowance for 200 allowances. The price, they said, reflected the cost of making the reductions. For each trade, the enterprises completed a contract and submitted it to TEPB. The bureau entered the trades in the ATS. Based on the reported emissions and the new allowance holdings resulting from the trades, each of the four enterprises was in compliance for the simulation.

To test another element of the trading system, TEPB sold 50 allowances in a sample auction using a two-stage bidding process. The first bids were submitted by Taiyuan Heavy Machinery (50 allowances at 1,000 RMB per allowance) and Dongshen Power Plant (30 allowances at 1,600 RMB per allowance). During the second stage of the bidding, bids were submitted by Taiyuan Power Plant 1 (20 allowances at 1,100 RMB per allowance), Taiyuan Heavy Machinery (50 allowances at 1,500 RMB per allowance), and Dongshen Power Plant (30 allowances at 1,650 RMB per allowance). After the bidding was closed, TEPB entered the results—30 allowances to Dongshen Power Plant and 20 allowances to Taiyuan Heavy Machinery—in the ATS.

TEPB concluded the test by assessing compliance, using the ATS to deduct the appropriate number of allowances from each account. The four enterprises all had sufficient allowances to cover their estimated emissions.

During a discussion about this test, enterprise representatives suggested that the auction should be an open bidding process involving all enterprises. They also asked TEPB to create an

information clearinghouse to publicize information relevant to the program, including potential buyers and sellers.

The simulation and RFF's experience in working with TEPB and the enterprises suggest a great deal of progress but also a number of ongoing needs. TEPB itself requested assistance and training on the following topics:

Administrative Operations: promotion of efficient operation of an emissions trading program through the establishment of an emissions trading office;

Standards for CEMs: establishment of guidelines for the certification, installation, operation, maintenance, and calibration of continuous emissions monitors;

Measurement and Control Technologies: development of information on available technologies for reducing SO_2 emissions; and

Emissions Trading Outreach: general training for high-level enterprise officials on the basics of participating in an emissions trading program.

■ ■ ■

CHAPTER SIX

Summary of Key Accomplishments and Recommendations

The adage "Rome wasn't built in a day" aptly describes the challenges involved in introducing emissions trading in Taiyuan, with its limited ability to administer and enforce a rigorous environmental management system—emissions trading or any other approach. Devising a workable means to meet the 50% emissions reduction targets of the Tenth Five-Year Plan is a daunting task. By way of comparison, a 50% reduction target was also established by the U.S. Clean Air Act Amendments of 1990, which form the basis of the highly successful U.S. SO_2 emissions trading program. In the U.S. case, however, the program was adopted after several years of serious study and debate, and the compliance period was stretched out over 10 years. Indeed, to give sources sufficient time to plan for and install control technologies, the program was phased in. During the first phase, only the largest, highest-emitting plants were included. It was not until five years after the start of the program that all affected sources were obligated to participate.

The specific accomplishments of this TA are many, including the promulgation of a formal regulation on emissions trading by Taiyuan City and the development and deployment of the management tools—the emissions and allowance tracking systems—needed to support trading. Equally or more important is the extensive investment in human capital made over the course of the TA, involving both senior officials and technical staff. Overall, we believe that the basic institutional and educational foundations for the SO_2 emissions trading program have been established in Taiyuan. Although challenges remain in moving to full-scale implementation, we are optimistic that the political will and institutional capacity are sufficient to support the operation of this innovative approach to improving air quality in Taiyuan. We expect that the resulting cost savings will fully justify the program.

This chapter has two principal purposes: to summarize the accomplishments of the demonstration project and to offer recommendations for the long-term success of the trading system. In considering both the accomplishments of the project and the recommendations for the future, it is important to recognize the particular circumstances of the environmental management system in the PRC. Accordingly, the first section of this chapter considers the definition of success. The second section reviews the accomplishments. The third section outlines the recommendations for future action.

We highlight various institutional issues concerning the way that emissions reduction goals are established in the PRC, the desirability of revisions to the emissions trading regulation

adopted in Taiyuan, and various issues related to allowance allocation, enforcement, emissions measurement, uncertainties related to banking, and others. At the outset, however, we would stress the following important but fairly simple point: many of these continuing challenges would apply to any system used in the PRC to achieve significant emissions reductions on the scale anticipated in the Tenth Five-Year Plan. Although emissions trading involves some particular issues related to the sale, exchange, and banking of allowances, arguably most of the other challenges are applicable to a conventional command-and-control system as well.

Defining Success

Establishing a program of emissions trading is somewhat like assembling a complex mosaic. A large number of intricate elements must be fit together. These range from technical components, like air quality monitoring, to policy-relevant and sometimes politically sensitive issues, such as developing a viable system design and establishing an appropriate legal framework. The exercise is not merely a matter of mechanically assembling pieces into a working whole. Many stakeholders and constituents must understand how such a program might work, agree it is in their interest to be part of the effort, and be trained to do their share in making it a reality. Thus, an important part of the demonstration in Shanxi Province includes capacity building for and with the people, institutions, and myriad potential participants in the trading program and developing fluency with and support for the principles involved.

To put the Taiyuan effort into some perspective, it is useful to recall the effort that led to introduction of the highly successful SO_2 trading program in the United States. That program was preceded by many years of theoretical and empirical analyses considering appropriate design features for a trading program, as well as more than 10 years of experiments with less sophisticated market-based instruments. The U.S. experiments and limited success with offsets, bubbles, and emissions reduction credits prompted a political debate over how to reduce SO_2 emissions of existing power plants—a debate that in 1990 led to the creation of the SO_2 allowance trading program in the Clean Air Act Amendments. This was followed by a four-year lead-in period in which the U.S. Environmental Protection Agency (EPA) wrote implementing regulations using notice-and-comment rulemaking procedures, which required extensive solicitation of public views, followed by the formal establishment of the emissions trading system. There was no need to construct an environmental enforcement system for these purposes because one already existed.

Interestingly, the target set in the United States was approximately a 50% reduction in SO_2 emissions from baseline, similar to the cap established in Taiyuan (a 50% reduction from 2000 levels). In the case of the United States, however, the reduction was phased in: the majority of the reductions were to be achieved in 2000 and the final goal reached in 2010—a full 20 years after the Clean Air Act Amendments were signed into law, rather than over the five-year period contemplated in Taiyuan.

The institutional and economic context for a trading program in the PRC differs. Although the levy system is a market-based instrument and has been a central feature of pollution control in the PRC for decades, the levies are generally too low to change the behavior of enterprises. The principal function of the levy system is to raise revenue. This is complicated by the fact that local environmental protection bureaus typically negotiate emissions reductions on a case-by-

case basis. Further, Chinese society is only beginning the process of moving toward a law-based framework, and local environmental regulators are struggling with basic issues of how to ensure compliance with environmental requirements and achieve regulatory independence.

In addition, although the PRC is a rapidly evolving market economy, there is only limited experience with complex markets to trade intangible commodities like pollution credits. A system in which state-owned industry is overseen by another arm of the state structure creates many inherent conflicts of interest. In similar economies, such as the countries formerly part of the Soviet Union, environmental regulators' lack of independence has compromised their ability to enforce environmental requirements, particularly when environmental goals collided with other important societal goals, such as production targets.

Overall, there is no single metric of success. A broad range of considerations and perspectives must enter any final evaluation.

Principal Accomplishments of the Demonstration Project

This section summarizes the six major accomplishments of the demonstration: education of government and industry leaders about the benefits of adopting emissions trading; promulgation of a formal regulation on emissions trading and establishment of an administrative framework to support the regulation; systems development and demonstration; capacity building and training for midlevel staff; publicity and public involvement; and the initial simulation of emissions trading among selected facilities.

Education of Government and Industry Leaders about the Benefits of Adopting Emissions Trading in Shanxi Province and Taiyuan City

One of the most important accomplishments of this demonstration project is the broad understanding and appreciation of the value of emissions trading gained by senior officials at the provincial and local levels of government. Although most of the training and capacity-building activities were focused on technical and midmanagement officials, considerable time was spent with senior officials of the provincial and local governments and with senior personnel in industry. Although it is difficult to summarize the results of these discussions, it is fair to say that the senior leaders in government and industry in Shanxi Province gained an understanding and appreciation of how emissions trading could be used to advance the goals of environmental management in the province, particularly in Taiyuan.

Promulgation of a Formal Regulation on Emissions Trading and Establishment of an Administrative Framework to Support the Regulation

A. Administrative Regulation on SO_2 Emissions Trading Program in Taiyuan. In October 2002, the Taiyuan City government promulgated a regulation for the emissions trading program, based on a draft proposed by the RFF team. The regulation contains provisions that create the legal basis for the program (Appendix 10 contains the full text of the regulation). Specifically, the regulation:

- assigns supervisory and administrative functions for the trading program to the Taiyuan Environmental Protection Bureau (TEPB);

- stipulates that the emissions cap should be based on the city's Total Emissions Control limit approved by the province;
- requires enterprises to report total mass emissions;
- authorizes the trading of allowances;
- requires enterprises to hold one allowance for each ton of SO_2 emitted during the year;
- establishes financial penalties for noncompliance with the regulation;
- authorizes enterprises to bank surplus allowances for use in the future; and
- requires the adoption of an emissions tracking system and allowance tracking system.

The regulation was signed by the mayor in October 2002, after extensive review at the city and provincial levels and comments from industry. Although some controversial issues remain, such as the cap on penalties, the Taiyuan regulation is notable as the first comprehensive regulation of its kind in China to support emissions trading on a citywide basis.

B. Allocation of Allowances. In December 2002, TEPB issued the future allowance allocations for each of the enterprises. The allocations were based on historical emissions data with a goal of reducing overall emissions by 50% relative to year 2000 emissions. Any enterprises, however, that had specific emissions reduction goals set in the city's Tenth Five-Year Plan received allocations equal to those goals. (See Appendix 8 for the allocation scheme of allowances for major enterprises in Taiyuan.)

C. Administrative Framework to Support the Regulation. To facilitate the implementation of the regulation, in 2002 the RFF team helped develop a procedural guidance document. The document lays out the functions and responsibilities of both the government and the enterprises, lists all the procedures that the government and enterprises need to follow in emissions trading, and presents the documentation (such as contracts for trading, emissions reports, and punishment notices) necessary for the administration of the program.

System Development

Unlike other pilot emissions trading programs in China, the Taiyuan project has two systems that were developed to facilitate the actual imp.lementation. The systems are the emissions tracking system and allowance tracking system.

A. Emissions Tracking System (ETS). The emissions trading regulation calls for a system to manage emissions reports from enterprises and TEPB monitoring bureau. Ideally, enterprises would measure emissions continuously, using stack monitors as required by the regulation. However, until it becomes technically and financially feasible for all enterprises to install continuous emissions monitors on each stack, alternative measurement methods are needed for some sources.

The ETS collects data on fuel inventories and fuel consumption as a basis for calculating total emissions during the compliance period. In addition to calculating emissions from mass balance formulas, the ETS collects data from the monitoring bureau to facilitate comparison of each enterprise's emissions measurements. Data about production levels are also collected to establish emissions rates (such as emissions per unit of output) that TEPB can use to identify possible data discrepancies with an enterprise's submission.

A mass balance approach is consistent with the intent and requirements of the Total Emissions Control policy, in which the State Environmental Protection Administration (SEPA) calls for continuous measurement of emissions throughout the compliance period. The ETS mass balance approach uses fuel consumption data to calculate total mass emissions from each source for the entire compliance period.

The ETS is a software application developed by the RFF team and initially distributed to enterprises and TEPB in mid-2002 and subsequently revised in December 2002. The application consists of several on-screen forms for enterprises to input data about fuel purchases, fuel consumption, product output, measured emissions, and so on. The enterprises can submit the data in electronic form to TEPB. Using the ETS, staff can transfer the data and compare each enterprise's emissions data against their own monitoring bureau's estimates.

B. Allowance Tracking System (ATS). The emissions trading regulation includes a provision that requires TEPB to establish a system to manage allowance allocations and transfers. The ATS is a software application developed by the RFF team that was installed at TEPB in December 2002. The application facilitates allowance accounting, including the creation of allowance accounts, issuance and allocation of allowances to the enterprises, transfer of allowances among enterprise accounts, and allowance deductions to offset emissions during the compliance year. In addition, the data and reports from the ATS can be used to publicize the results of the trading program.

Capacity Building and Training

In cooperation with U.S. EPA, training sessions were held on the basics of emissions trading, design elements of emissions trading programs, the importance of accurate emissions measurement, the role of computerized tracking systems to manage emissions and allowance data, enforcement needs, and how to participate in the Taiyuan emissions trading program. Table 6.1 lists the seven training sessions held in Taiyuan from May 2001 to December 2002, along with the content of each session.

Publicity and Public Involvement

SEPA is now publicizing the idea of using a market-based approach to controlling SO_2 and conducting demonstration pilot projects nationwide. In March 2002, SEPA announced that Shanxi Province, together with Shandong, Henan, and Jiangsu provinces as well as the cities of Shanghai, Tianjin, and Liuzhou, would pioneer the PRC's first interprovince trading scheme.[30] To this end, the Taiyuan demonstration has gained considerable prominence. In a workshop sponsored by SEPA and U.S. EPA in November 2002, Taiyuan's experience with emissions trading was presented as a case study.

China Environmental News, the major newspaper in the PRC for environmental issues, reported the progress and success of this TA project in Taiyuan on October 18, 2002. Staff at TEPB, the implementing agency, have received numerous requests for interviews about the project from both TV stations and newspapers.

The Taiyuan project also generated considerable global attention. The first international story appeared in *The Economist* magazine on May 9, 2002. Subsequently, other international publications also reported on the Taiyuan demonstration. RFF has also provided information about the

TABLE 6.1

Training Sessions about Emissions Trading Program in Taiyuan

Dates	*Trainees*	*Content*
May 14–18, 2001	Shanxi Planning Commission, Shanxi Environmental Protection Bureau(EPB), TEPB.	Emissions trading programs in general and particularly in the United States.
		General principles for the design and demonstration of an SO_2 emissions trading program in Taiyuan.
December 17–20, 2001	TEPB, industry representatives.	Emissions monitoring and allowance tracking.
April 9–12, 2002	TEPB, industry representatives.	Demonstrations of emissions and allowance tracking systems developed by RFF and U.S. EPA
June 10–12, 2002	Shanxi EPB, TEPB, industrial managers.	U.S. SO_2 emissions trading experience.
		Emissions and allowance tracking system.
		Emissions trading interactive simulation.
September 6–12, 2002	TEPB, industry representatives.	Demonstration of the ETS software to TEPB.
		Demonstration of the ETS software to participating enterprises.
		Demonstration of the ATS software to TEPB.
November 7–14, 2002	TEPB, industry representatives.	Issuance of regulation to enterprises.
		Explanation of procedural guidance for enterprises to implement emissions trading.
		Discussion on enforcement and compliance issues of the trading program.
		Use of ATS software.
		Cost analysis.
December 16–18, 2002	TEPB, industrial managers.	Test of procedures and systems for operation of the emissions trading program.
		Test trade among four selected enterprises.

project through *Resources*, an RFF publication that has a wide print and electronic circulation.[31] In writing the "Background Paper on Emissions Trading in China," Civic Exchange, a Hong Kong–based public policy think tank introduced this project as one of the case studies about emissions trading in China.[32]

Initial Simulation of Emissions Trading among Selected Facilities

In December 2002, the RFF team helped test the operation of the emissions trading program by creating a hypothetical compliance year and running the procedures for account creation, allowance allocation, emissions reporting and verification, allowance trading, auction operation, and compliance determination with four selected enterprises. The test trades helped give both TEPB and the enterprises further insights about how the trading would occur, how the system works, what steps to follow in conducting trades, and what signals to use for trading prices of the allowances.

Recommendations

This section presents 16 specific recommendations designed to advance the use of emissions trading in Taiyuan and elsewhere in Shanxi Province. Some of the recommendations are technical adjustments to the emissions trading plan; others are for institutional strengthening; and others are for improving coordination and information flows.

Technical Adjustments to the Emissions Trading Plan

A. Loosen the cap on penalties. Article 23 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City sets a yearly cap of 30,000 yuan on the total penalties that can be assessed against polluters. Specifically, the regulation states: "If the polluters' actual annual SO_2 emissions exceed the SO_2 emissions allowance they hold at the end of the same year, they shall be fined by the environmental protection department 3,000 to 8,000 yuan per ton of excess emissions, and the maximum penalty shall not exceed 30,000 yuan."

The obvious difficulty with this provision is that if the cost of compliance (installing technology, making process changes, or purchasing allowances) is greater than the maximum allowed penalty, enterprises have strong incentives to be out of compliance and simply pay the capped penalty. In various meetings among the RFF team and enterprise representatives, compliance disincentives associated with the penalty cap were extensively discussed. In fact, several enterprise representatives indicated that the penalty cap would discourage them from reducing emissions, since it would be cheaper to pay the fines.

The RFF team has had extensive discussions with provincial and local officials about this issue. We have also pointed out that this is a problem not simply for an emissions trading system but for any other form of environmental management system as well. The response is that although the local and provincial officials recognize the importance of raising the cap to encourage greater compliance (with any system), their legal advisers insist that action by the Provincial People's Congress would be required to authorize such a step. Informally, they have agreed to monitor the progress of the demonstration and, based on that experience, submit a request to the Provincial People's Congress at some future (unspecified) date.

Recommendation: Specific actions should be initiated in the near term to develop a formal request to the People's Congress to lift the penalty cap. Subsequently, Article 23 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City should be modified to reflect the action of the People's Congress.

B. Clarify allocation policy for modification, expansion, and other changes at firms. Article 11 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City stipulates that: "Modification, expansion, amalgamation, and separation of existing polluting sources will not increase SO_2 allowances. A new enterprise in the trading program can acquire allowances from other enterprises, or get allowances in the allocation of the next Five-Year Plan." This provision creates a potential barrier to mergers and consolidations that may be beneficial to the local economy and does not appear to be necessary for success of the emissions trading program.

Recommendation: Article 11 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City should be modified to remove the requirement that allocations of acquired firms be reduced from the allocation of the acquiring firm. It is recommended that decisions on mergers involving firms that do not participate in the trading program be negotiated on a case-by-case basis.

C. Permit allowance use after plant shutdowns and central heating connections are made. Article 10 of the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City states: "In case of reductions in SO_2 emissions because of conversion to central heating, plant shutdown, merger, relocation and bankruptcy of enterprise, etc., the city environmental protection department shall take back or adjust the emissions allowance of the polluters." It is reasonable that the city should take back emissions allowances when central heating results in the closure of boilers. In the case of shutdown and bankruptcy, revoking allowances also is reasonable. However, mergers and relocations generally would not be good reasons for revoking allowances. If there are special circumstances involving mergers and relocations under which revocation or adjustment of allowances is desirable, TEPB should provide guidance.

Recommendation: The broad-scale requirement that allowances be returned to TEPB after plant shutdowns and central heating connections are made should be removed from the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City, and further clarification should be provided.

D. Allow banking. The emissions trading regulation specifies that enterprises must seek approval from TEPB before using banked allowances to cover emissions from the compliance period. This provision is intended to prevent emissions from increasing beyond acceptable levels during any particular period. Because applications to use banked allowances are not evaluated until the end of the compliance year, an enterprise will not know the outcome of its application until after the compliance year is over and thus have no opportunity to further reduce emissions or purchase allowances from other enterprises if the request is denied. Therefore, this provision effectively prevents banking of surplus allowances. Loss of this feature will raise the costs of meeting the caps without any significant environmental benefits. Concerns that the banking provisions may allow emissions to increase beyond acceptable levels do not seem warranted. In the United States, the banking provisions are credited with increased emissions

reductions in the early years of the program. Experience also shows that some emissions will always be in the bank as insurance against future need, which tends to create additional environmental improvement.

Recommendation: This provision should be modified to allow banking of surplus allowances without prior approval by TEPB.

Institutional Strengthening

A. Improve emissions measurement. Over the past several years the PRC has implemented the policy of Total Emissions Control. This policy places a national cap on particulate and SO_2 emissions, then apportions this cap to provinces, and later to cities and individual sources. Fixed allocations of emissions to individual sources is an essential prerequisite of emissions trading.

A cornerstone of any successful emissions trading program is the accurate quantification of emissions: if emissions cannot be accurately measured, they cannot be managed. Ideally, measurement is done with continuous emissions monitoring (CEM) devices. However, alternative protocols can also be used so long as there are checks to ensure their integrity. Currently, TEPB employs a technique for measuring emissions that is sound in principle but potentially inaccurate in at least two respects. TEPB computes the volume of air going up the stack by measuring air speed and the stack diameter. Several measurements of air speed are taken at different places in a stack cross section and volume is computed. Then concentrations are sampled at several points in the stack cross section. Concentrations are measured at least three times at each point and an average concentration is computed. Then volume is estimated again. If the two volume estimates differ by no more than 5%, they are averaged and accepted. If the difference is larger, then more air speed samples are taken. Emissions are calculated by multiplying volume by concentration by hours of operation as reported by the firm.

Firms also measure their own emissions—often using the same procedure, but also relying on alternative methods where appropriate. TEPB applies a weight of 70% to its estimates and 30% to the firm's estimate in developing a final emissions estimate. The RFF team was able to review some of these emissions estimates and found very large differences (several-fold) in some instances but close agreement in other instances. Surprisingly, firms reported emissions estimates higher than TEPB about as often as they reported lower numbers.

The TEPB procedure is likely to yield a highly accurate estimate of emissions while the measurements are taking place. The principal weaknesses are (1) reliance on the firm to report hours of operation, and (2) the assumption that emissions during the sampling hours are representative of emissions at other times. If emissions become costly to firms as a result of progressively lower allocations, there will be an incentive to underreport hours of operation. The assumption may not be warranted, since firms generally have advance notice of TEPB inspections and may be able to adjust the quality of fuel and fuel use during that interval.

TEPB officials understand the desirability of improving the estimates of emissions and, in fact, mandated CEMs for all boilers in excess of 40 tons by December 31, 2002. However, because of the relatively high cost of CEMs and limited funds available for pollution-control investment, many enterprises in the trading program were unable to meet this deadline. The RFF team proposed the emissions tracking system as an alternative protocol for estimating emissions. The ETS is based largely on coal consumption and the sulfur content of that coal. It requires

identifying vendors of coal as a means of increasing overall transparency and accountability. Despite the obvious advantages of the ETS, its use would require some additional effort and could produce estimates that diverged from those based on existing protocols. In a possible compromise discussed in December 2002, TEPB would continue using its current protocol but have enterprises use ETS for their estimates. The 70–30 weighting of TEPB estimates relative to those of enterprises would continue.

Data management by TEPB also is a cause for concern. Firms need to have reasonably current information on emissions to make emissions control decisions and to trade allowances. Yet during a site visit, TEPB could produce emissions estimates for only about two-thirds of the firms participating in the allowance trading program. Further, these estimates were for the first six months of calendar year 2002. In early November 2002, no information was available regarding emissions after June 30.

Recommendation: TEPB should focus additional management and technical resources on emissions measurement and management of the emissions data. Without accurate and timely measurement of emissions, it will not be possible to achieve major emissions reductions in Taiyuan via emissions trading or any other approach.

B. Augment financing for emissions controls. Although trading allowances have the potential to lessen the immediate and longer-run financial burden on firms with responsibilities to cut emissions, substantial emissions control investments will be required. Firms generally have several possible sources of financing pollution control investments: (1) internally generated funds; (2) return of a portion of pollution levy payments; (3) bank financing; and (4) lending by international financial organizations.

Internally generated funds historically have been the most important source of pollution control funding in enterprises in the PRC and likely will continue to be so. Unfortunately, several of the enterprises participating in the Taiyuan emissions trading program are not profitable and may be unable to self-finance needed pollution control investments.[33] The return of pollution levies has been an important source of funds for pollution abatement activities; however, this situation is changing with the reform of the pollution levy system. In the future, the levy funds will no longer be returned automatically to the firm. Rather, firms will have to compete for funding in the form of loans. Bank financing of pollution control equipment has always been a difficult proposition, since these investments seldom produce the positive returns that banks typically require. It is not clear that the additional costs of pollution control can be passed forward in product prices because of competition from firms outside of Taiyuan. Finally, international financial organizations tend to become involved only in larger projects and cannot be relied upon for routine lending of this sort. Moreover, a Ministry of Finance directive (Circular 1, January 2000) appears to preclude lending by international financial organizations to competitive enterprises.

Recommendation: The provincial and national governments, possibly in coordination with international financial institutions like ADB, should consider providing additional financing assistance for pollution control equipment, especially to enterprises participating in emissions trading programs.

C. Improve enforcement. Steady, reliable, fair enforcement and a well-constructed program to detect and act on violations are basic building blocks of any environmental management system to control environmental pollution, whether that system uses traditional or market incentive-based tools.

One of the significant issues facing Taiyuan environmental officials is how to ensure that enterprises are following the rules and that real emissions reductions are being achieved. As they seek to accomplish this, the Taiyuan enforcement officials face several challenges. One is that they have only a limited number of enforcement tools—mostly the power to collect fees and fines and to shut plants down (almost always temporarily) to curb immediate exceedances perceived as threatening. The fees and fines provide revenue for TEPB, with the balance circulated back to enterprises for environmental improvements. Raising the penalties would be one solution, although as noted, the People's Congress would need to approve any increase in the penalty cap. It would also help if officials had at their disposal additional tools to encourage compliance, such as administrative orders, civil and criminal penalties, authority to issue compliance schedules, and the like.

If enterprises do not know what their real and actual targets are, they may be tempted to take a wait-and-see attitude rather than invest in pollution control.

Recommendation: TEPB should broaden the set of enforcement tools used to encourage compliance. For example, it is recommended that unannounced inspections be increased, missing data procedures be established, a clear chain of command for taking enforcement action be developed, and a penalty structure be set up that explicitly accounts for *de minimis* as well as large violations.

D. Set realistic but firm emissions reductions targets in five-year plan. As noted in previous chapters, emissions targets are established in the five-year plans and don't appear to have been set with any explicit consultation with industry about what it considers feasible and what technologies are available (particularly in the local market), at what cost, and with what type of financial assistance. As a result, there are serious questions about the credibility of the national and provincial targets and thus also about the usefulness of these targets as a basis for establishing the enterprise-specific targets.

A second issue is the time frame for meeting the target, which is extremely short for such an ambitious goal. Further, the specific goals are being developed and sometimes rethought within the specified time for compliance—that is, within the five-year period in which they are supposed to be achieved. This further shortens the time for industry to undertake its share of the responsibilities.

Experience in the United States indicates that industry needs adequate time to plan environmental investments. The extended period in which goals are set in the United States and then built into plant-specific permits is one way in which industry is put on notice of its ultimate responsibilities and has time to plan and finance the specific activities necessary to come into compliance. The decisions include whether to install technology or make other adjustments to reduce emissions or to purchase allowances. Our experience indicates that even after industry identifies the kind of technology it must install, the desired equipment isn't always immediately available. Similarly, financial analysis is necessary to determine whether to purchase al-

lowances and at what price. It is certainly appropriate to make adjustments and update allocations every five years, but sources need enough certainty to plan investments properly. Moreover, experience in the United States suggests that if industry senses that goals will be eased, some plants will wait, often until the last minute, to undertake their responsibilities, on the chance that they won't have to make the environmental investment.

The RFF team believes that small modifications to the planning process might improve the likelihood of real emissions reductions. One way is to build into the planning process explicit consultation among industry, environmental regulators, and enforcement officials as the targets are being established. Opportunities as well as obligations for cleaner production should also be considered. Emissions reduction goals appropriately represent a combination of political and technical judgment. It currently appears that the goals are set in a relatively closed process and then announced to these important stakeholders. As a result, such goals may reflect political ends, but they may not be realistic about what is practical within the relevant time and economic constraints. A more inclusive process might increase the planners' understanding of what is feasible, what technology is available, the costs of compliance, and other factors that affect the likelihood of achieving genuine reductions.

If the goals and targets consistently overreach, they seem destined to be modified as reality sets in. If, on the other hand, the planners interact with the groups and enterprises that are the subject of the targets, they will have more information and can set targets that are not only ambitious but also achievable.

Recommendation: The goal-setting process should be reformed to more explicitly account for economic, technical, and financial feasibility and to incorporate explicit consultation with industry in advance of establishing the formal goals. This recommendation applies to goal setting at all three government levels—national, provincial, and local.

E. Establish realistic but firm emissions reduction targets for Taiyuan sources. During 2001 and through the first six months of 2002, overall progress appeared slow. Table 6.2 identifies the participants in the Taiyuan SO_2 emissions trading program along with their estimated emissions for calendar years 2000, 2001, and the first six months of 2002. The table also gives the 2002 and 2005 allowances for these firms (as of November 2002). For enterprises for which data for 2000, 2001, and six-month 2002 emissions data are available, aggregate emissions were 124,171 tons in 2000, 124,388 tons in 2001, and 61,992 tons for the first six months of 2002, or an estimated annual rate of 123,984 tons. Overall, progress during the first 18 months of the 2001–05 period has amounted to an overall reduction of just 0.15%, versus the 50% or more reduction required for the remainder of the five-year period.[33]

One explanation for the relatively slow progress is the difficulty some firms have had in obtaining 1% sulfur coal because of the closure of many small mines and the high demand for low-sulfur coal outside the region. A second important factor is that Taiyuan Power Plant 2 has removed a primitive wet method for dust control and installed electrostatic precipitators. The wet method of dust control formerly captured nearly one-half of the SO_2 emissions. The plant intends to install flue gas desufurization for some of its stacks; however, financing remains an issue.

There are also encouraging signs of progress. Some firms appear to be well on their way to achieving their 2005 emissions targets and in fact would have excess allowances to sell for 2002.

TABLE 6-2

Emissions and Allowances for Participating Enterprises

Enterprise	Emissions 2000 (T)	Emissions 2001 (T)	Allowance 2002 (T)	Emissions first 6 months 2002 (T)	Allowance 2005 (T)
Taiyuan Power Plant 1	60,624	56,321	51,117	23,792	16,000
Taiyuan Power Plant 2	35,669	40,800	35,870	24,584	17,000
Taiyuan Steel & Iron	21,033	22,006	19,000	11,358	9,000
Taiyuan Heavy Machinery Group Co.	2,194	1,178	1,405	499	980
Taiyuan Gangyu Dongshan Plant	1,472	1,672	1,501	861	820
Taiyuan Railway Branch Bureau	1,190	360	600		288
Fertilizer Plant of Taiyuan Chemical	699	419	547	60	251
Taiyuan Shitou Cement	648	537	486	255	324
Xinkai Textile and Dyeing	417	340	309	142	210
Taiyuan Locomotive Vehicle Plant	369	307	280	125	185
Taiyuan Heatin Co.	542	350	340		200
Taiyuan Aluminum Plant	143	102	103	64	60
Dazhong Machinery Plant	281	245			147
Taiyuan Aircraft Instrument Co.	389	351			210
Fenxi Machine Factory	120	132			79
Shanxi Machine Manufacturing Co.	132	92			55
Shuangxi Tyre Industry		385			230
Chemical Plant of Taiyuan Chemical	428	187			113
Coking Plant of Taiyuan Chemical	903	706	697	252	423
Taiyuan Cigarette Factory	316	372			223
Huayuan Electronic Chemical		704	292	230	350
Shanxi Coking Coal Co. Group		4,529			1,739
Coal Gas Company of Taiyuan		4,468			2,880
Xinan Chemical Material Plant		66	66	33	40
Shanxi Machinery Station Plant		260			100
Jinxi Machinery		462			180

Among these firms are Power Plant 1, Taiyuan Heavy Machinery Group Co., Xinkai Textile and Dyeing, Taiyuan Locomotive Bureau, and the Coking Plant of Taiyuan Chemical Co. If trading had been allowed for 2002 emissions, these firms could have banked excess emissions or sold them to other firms.

Recommendation: TEPB should evaluate progress to date and develop a realistic timetable for firms to come into full compliance. If the original target is still valid, that point should be clearly made to the enterprises. If some leeway in meeting the target is anticipated, that should also be clearly articulated. In general, uncertainty about binding regulatory requirements is not conducive to environmental progress.

F. Conduct additional training. Education is the key to developing an understanding of the complexities involved with designing and operating a regulatory program. Many environmental professionals, particularly at the local level, do not have adequate access to training materials. Yet studies have shown that education and technical assistance can dramatically increase compliance with environmental programs.[34]

The RFF team has conducted several training sessions (see pages 66 and 67) for TEPB and enterprise managers. To date, training has focused on program design and requirements. Additional training on the operation of and participation in the emissions trading program would benefit both TEPB and the enterprises.

Recommendation: Conduct additional training on program operation, emissions measurement, and measurement-and-control technologies. Domestic funds could support such activities, and funds from ADB Loan 1715-prc could also be used.

G. Continue research and analysis as the system moves into full-scale operation. International experience with emissions trading and other environmental management systems suggests that new issues tend to be identified once the system becomes fully operational. For example, one issue that has recently arisen in model simulations is the potential for emissions trading to have (somewhat) disproportionate air quality impacts in different zones in Taiyuan, depending on the nature (and direction) of the trades. As the system becomes fully operational it would be appropriate to examine this issue further, with the possibility of revising the trading rules, if warranted.

Recommendation: Continue research and analysis as the emissions trading system becomes fully operational. Be prepared to revise the system as needed.

Improving Coordination and Information Flow

A. Improve policy coordination among different levels of government. Currently, there appears to be only limited coordination among national, provincial, and local governments concerning innovative policies such as emissions trading. Although there is no universal practice in this regard, in many countries national agencies often take the lead on such innovations, typically providing technical (and sometimes financial) support to provincial or local agencies. In Shanxi Province several environmental initiatives are already under development that could benefit from closer coordination among the three levels of government. For example, discussions are under way concerning the establishment of a province-wide emissions trading program focused on

power plants. Yet there appears to be little coordination among the different levels of government on how such a system would operate and, in particular, how it would interface with the Taiyuan emissions trading system.

Recommendation: The emissions trading demonstrations should be more closely coordinated within Shanxi Province and among the various levels of government. Specifically, plans to develop a province-wide emissions trading program in the electric power sector should be integrated with the Taiyuan emissions trading demonstration. It might be possible to pursue support for capacity building from ADB or other international organizations to carry out this integration.

B. Establish a mediation committee. An honest broker that can settle disputes between trading partners and manage differences between the regulatory authority and industry traders is essential because, as noted earlier, inevitably disputes will arise. In the absence of independent courts with adequate skills and jurisdiction, one option would be to establish a project mediation committee as a neutral and respected forum for dispute resolution. Such a committee could comprise senior officials of relevant government institutions, including the planning commission, and representatives of enterprises. It could also include representatives of academia, the media, and the public as a means of ensuring the openness of its deliberations. Ideally, the committee would function in a relatively transparent manner, issuing written decisions or hearing disputes in relatively open sessions.

Recommendation: Establish a mediation committee to provide a forum for resolution of possible disputes that can arise in the context of an emissions trading regime.

C. Make information about emissions trading programs publicly available. The old saying "sunshine is the best disinfectant" has characterized U.S. emissions trading programs, such as the acid rain SO_2 trading regime. Virtually the entire program is subject to public inspection, so it is extremely easy for the public to obtain information about allowance allocations and actual trades. U.S. experience has demonstrated that this helps prevent cheating and corruption of the program and thereby builds public confidence. The availability of information helps assure people that trades are legitimate, that any grants of discretion to a plant are not based on favoritism, and that the system isn't enriching plant owners or operators, regulators, or other vested interests at the expense of the environment.

A similar campaign to inform the public in the PRC may reduce suspicions that the program has been instituted to benefit favored units and can increase support and understanding of the goals of emissions trading. As noted earlier, it would also fit well with the PRC leaders' interest in increasing public environmental awareness.

Recommendation: Since the TEPB has already agreed to create a Web page, we recommend that this Web page be used to provide participating enterprises and the public with information about the details of the program, including emissions, allowance trades, and compliance, in a format that will increase understanding of emissions trading and minimize suspicion that might taint the program.

D. Establish an advisory group to assess Taiyuan's emissions trading demonstration. Discussions in the course of the project highlighted the need for clear and unequivocal demonstrations of support by high-level Taiyuan City and Shanxi Province government officials. Firms are more likely to support the trading program when they understand that the government is serious about reducing emissions, and that it stands behind a program to reduce emissions in the most efficient manner. As a result, we suggest that the Shanxi Planning Commission convene an advisory group of government officials and industry managers in Taiyuan to assess the overall demonstration and a working group of technical staff to monitor the detailed operation of the demonstration. The former group can provide the kind of political support that will encourage widespread participation by industry. The working group can identify problems and solutions as the system is developed. Both will increase the sense of domestic ownership of the program and thereby increase the likelihood of success.

Recommendation: Establish an advisory group to assess the Taiyuan demonstration and a working group of technical staff to monitor the detailed operation of the demonstration.

E. Analyze the incentives for trading and publicize the benefits to enterprises. A major issue that warrants careful examination concerns the actual incentives for enterprises to participate in emissions trading programs in Taiyuan. Experience in the United States suggests that enterprise managers need more than a theoretical understanding of the benefits of trading; they make decisions based on actual expenses and experience. In the United States, industry has been subject for a number of years to regulatory demands and relatively consistent enforcement for noncompliance (including the possibility of citizen lawsuits). It is at least arguable that incentives for participating in emissions trading programs are closely related to industry's appreciation of the risks of noncompliance. Until the message is made clear to enterprises that compliance is mandatory (that they must install technology or purchase emissions allowances or both), it is difficult to predict whether enterprises are likely to take an emissions trading program or any other regulatory program seriously. When the message is that compliance obligations may be malleable and potentially subject to change through negotiation, the main incentive for trading—the opportunity for cost savings against real expenditures toward compliance—is diminished. Few enterprise managers make investment decisions based on theory.

In principle, as discussed in Chapter Three, the considerable variation in the overall cost-effectiveness of SO_2 control creates the opportunity for achieving emissions reductions through a trading regime, since enterprises will seek the most cost-effective means of complying. A second incentive for trading arises if the year-by-year schedule of emissions reductions for each enterprise does not match well with the available technological options. In that case, firms may want to bank or sell excess emissions in some years and buy allowances in other years. Some trading for this reason can be expected, and many sources would likely benefit from this added flexibility. A third rationale for trading arises when there is "lumpiness" of available control technologies (see Chapter Three). Unfortunately, we do not have enough information to determine the full extent of such scale economies.

Recommendation: Particularly as the emissions trading program begins operation, TEPB should continue to analyze the incentives for emissions trading and should publicize the results of trades, both within the regulated community and beyond.

Notes

1 Originally, Dan Millison served on the project team as an environmental specialist in the early phase of the project. However, because of other commitments he withdrew from the team in late 2001.

2 Wang, Hua, and David Weeler, "Endogenous Enforcement and the Effectiveness of China's Pollution Levy System." World Bank Development Research Group, Washington, DC. 2001.

3 Finamore, Barbara, and Tauna Szymanski, Taming the Dragon Heads: Controlling Air Emissions from Power Plants in China. Taipei: National Resources Defense Coucil. 2002.

4 For example, see contrary argument by Daniel H. Cole and Peter Z. Grossman in "When Is Command and Control Efficient? Institutions, Technology, and the Comparative Efficiency of Alternative Regulatory Regimes for Environmental Protection," *1999 Wisconsin Law Review* 5: 887 and Daniel Cole's "Toward a Total Cost Approach to Environmental Instrument Choice." In R. Zerbe and T. Swanson (eds.), *Research in Law and Economics*, 2002.

5 Carlin, Alan, "The United States Experience with Economic Incentives to Control Environmental Pollution." EPA Office of Policy Planning and Evaluation, EE-0216, July 1992 (available at www.epa.gov/economics).

6 Harvard Institute for International Development, "Market-Based Instruments for Environmental Management in the People's Republic of China," paper submitted to the Asian Development Bank (TA No. 2951-PRC), May 1999.

7 The new Air Act was adopted at the 15th Meeting of the Standing Committee of the Ninth National People's Congress on April 29, 2000, promulgated by Order No. 32 of the President of the People's Republic of China on April 29, 2000, and effective on September 1, 2000.

8 See "Key Aspects of the 2000 Amendments to the Air Pollution Prevention and Control Law of the People's Republic of China, Briefing for Corporate Counsel and EHS Managers," Albert Beveridge and Henry Diamond, P.C., 2001 (available at www.bdlaw.com/ publications.asp). One of the authors of this briefing paper was formerly the chief environmental law drafter for the Chinese National People's Congress.

9 Taiyuan will be the first city in Shanxi Province to do this.

10 During the ninth five-year planning period, vehicle pollution was reduced by phasing out lead from gasoline and mandating that tailpipe emissions meet the applicable standards.

11 For example, the Taiyuan Coal Gasification Company planned to build a 26-MW power station to burn low-quality coal (*gangue*) with three new 35-ton/hour fluidized furnaces. Even with dust removal treatment, an additional 660 tons/year of dust would be emitted, and the factory would exceed allowed emissions. Emissions exchange was required by Taiyuan to offset the new pollution. The new power station was required to supply

heating to the Coal Separation Factory and the nearby Taiyuan Cement Factory, so that a 41-ton/hour boiler could be decommissioned, resulting in a 298-ton/year reduction in dust. Further, the Xishan Industry Bureau, an affiliate of the gasification company, will construct a coal gas extraction project in DuErPing Mine for local residents. Under an agreement with TEPB, the gas extraction project was treated as an environmental offset project for the gangue power station. The gas extraction project is expected to benefit 5,000 households and some restaurants and other boiler users. As a result, approximately 20,000 tons of coal would be saved, resulting in a 270-ton/year reduction in dust. The new emissions source will be balanced by the reduction in existing emissions sources, achieving TEC requirements.

The Taiyuan Fertilizer Manufacturer is another example. It plans to build a 60,000-ton/year soda workshop. Despite the new production process, cyclone and static-electric dust collection, additional emissions could not be fully offset because of the significant increase in production. The firm agreed to provide 150,000 yuan as an environmental offsetting fee to pay for control of dust emissions from nearby boilers.

12 Other policies contributing to reducing emissions are as follows:

- pollution control within deadlines (roughly analogous to administrative cleanup and abatement orders in the United States);
- *san tong shi*, or Three Simultaneities (requiring that pollution control be incorporated in design, construction, and operation of industrial projects);
- pollution levy system (currently the SO_2 charge is collected based on total SO_2 emissions, and levies are collected on other pollutants exceeding concentration standard); and
- use of CEMs for boilers and other large process units (although TEPB is promoting CEMs, only a limited number of large pollution sources have actually installed them).

13 A survey of small boilers subject to the closure requirements indicates quite dramatic reductions in SO_2 emissions from these sources. See Morgenstern, Richard, Alan Krupnick, and Xuehua Zhang, *The Ancillary Carbon Benefits of SO_2 Reductions from a Small-Boiler Policy in Taiyuan, PRC*. Discussion Paper 02–54, Resources for the Future, Washington, DC. September 2002.

14 The SEPA-approved formula for estimating SO_2 emissions from coal combustion is as follows: SO_2 emitted = tons coal × %S × 2 × 80% The factor of 2 is the molecular weight conversion of S to SO_2; the 80% factor is for fractionation of some sulfur into ash.

15 Some of these aspects are considered in the proposed design for emissions trading in Taiyuan, as described in Chapter Four.

16 In the United States, for example, detailed engineering analysis of the control options available to one particular power plant revealed that the marginal abatement costs declined dramatically in the range of 70% to 80% reductions. See Leland Deck, "Visibility at the Grand Canyon and the Navajo Generating Station." In Richard D. Morgenstern (ed.), *Economic Analyses at EPA: Assessing Regulatory Impact*, Resources for the Future, Washington, DC, 1997, 267–302.

17 Harvard Institute for International Development, "Market-Based Instruments for Environmental Management in the People's Republic of China," paper submitted to the Asian Development Bank (TA No. 2951-PRC), May 1999.

18 As a caution, it should be noted that the marginal abatement cost for electric power and district heating plants rises significantly with increasing reduction rates. For example, FGD typically involves marginal abatement costs in the range of 1,500 RMB per ton. Because electric power and district heating plants were targeted for pollution control by the national government during the late 1990s, the lowest-cost options identified in the table probably have been implemented.

19 Liang, Nian, Zhihong Liu, and Xiulan Gao, "A Projection on Industrial Pollution Discharge and Abatement Cost in China," presented at the Seminar on the Economics of Industrial Pollution Control in China, World Bank, September 8, 1998.

20 Low-sulfur coal, averaging 1% sulfur, has been mandated in Taiyuan since 2000. Some firms are able to buy such coal, but many are not because of the closure of many small mines and the high demand for low-sulfur coal in Beijing and elsewhere (including exports). During 2001 and the first half of 2002, firms contacted by the RFF team reported using coal with an average sulfur content of about 1.15%.

21 To more firmly establish in advance the likely gains to be achieved from emissions trading as well as the likely price of allowances in Taiyuan, we developed a survey questionnaire to be administered to the participating enterprises. The questionnaire was designed to elicit information in several different areas:

- industrial output, total SO_2 emissions, and environmental management;
- coal consumption and sulfur content;
- SO_2 emissions control equipment or procedures in place on individual sources; and
- future SO_2 emissions reduction plans.

In September 2001, a member of the RFF team traveled to Taiyuan to meet with the representatives of the enterprises to explain the purpose and content of the questionnaire and to distribute it to the 26 enterprises identified by TEPB to participate in the demonstration. Unfortunately, and despite followup efforts by both the RFF team and TEPB, only 15 of the 26 enterprises completed even a portion of the questionnaire (58% response). Only 10 enterprises provided information on current SO_2 treatment conditions, and only four provided information on future reduction plans—and some of that was incomplete. In sum, results from the questionnaire were disappointing. Much better data were obtained during site visits to about one-half of the firms in the trading program during May 2001 and May 2002.

22 Burtraw, Dallas, et al., *The Effects of Allowance Allocation on the Cost of Carbon Dioxide Emissions Trading*. Discussion Paper 01–10, Resources for the Future, Washington DC. August 2001.

23 This rule has been discussed on page 27. It is part of the legal basis for the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City.

24 The U.S. EPA and SEPA are working together to propose standards for the certification, installation, operation, maintenance, and calibration of CEMs.

25 See X. Zhang, *Institutional Constraints on China's Environmental Enforcement: A Perspective of Local EPB Personnel*, M.A. thesis, Western Washington University, March 2001, 7.

26 Interestingly, in December 2002 one of the enterprises noted that it was fined more than 50,000 RMB for a violation. The size of penalty imposed for violations remains a key to the success of the emissions trading system or any other systems adopted in Taiyuan.

27 As noted previously, this arrangement will change in the near future.

28 Originally, it was planned to create a Web site to manage the emissions data. However, after discussions with TEPB staff and enterprise managers, it was decided that a non-Internet–based tracking system would be preferable. Accordingly, the ETS was substituted for the Web site development.

29 The software was designed using the Chinese language to permit local enterprise and government use. Here are just one sample table and one sample graph. The table requires the enterprises to report basic situation, such as name and contact. The graph shows the changes of SO_2 emissions by selected enterprises over time.

30 The news is available at www.dckonsult.com/news-envir-air.htm.

31 The *Resources* article is available at www.rff.org/resources_archive/pdf_files/148_emissions.pdf, 2002.

32 The background paper is available at www.civic-exchange.org/publications/2001/Emissions finale.pdf, October 2001.

33 There are many gaps in the table. Some gaps are due to the fact that not all firms had been given their allowances at the time the data were made available. Other gaps result from inconsistencies in an earlier compilation of firms in the program, and still others are the consequence of mergers and changes in the list of program participants. There are reasons for concern as well as for optimism in the available figures.

34 Dasgupta, Susmita, "Opportunities for Improving Environmental Compliance in Mexico," World Bank Development Research Group, Environment and Infrastructure, Working Paper 2245. Washington, DC: The World Bank, 1999.

APPENDICES

APPENDIX I

Summary of the Field Trips between March 2001 and April 2003

Since March 2001, the RFF team has made 15 trips to Taiyuan. Through the fieldwork, we have gained a sound understanding of local environmental, economic, and institutional conditions. We completed an inception report, a midterm report, and a final report; conducted a survey of the 26 enterprises in September of 2001; successfully allocated yearly allowances to individual enterprises in October of 2001; drafted the local regulation and implementation guidance of SO_2 emissions trading; and conducted a series of training workshops. At the end of 2002, the regulation was approved by Taiyuan Government and entered into force, test trades among four selected enterprises were made in December of 2002. The final tri-partite meeting was held in September 1, 2003.

Summary of the Field Trips between March 2001 and April 2003

Dates	Participating team members	Major activities
March 18–29, 2001	RFF: Dick Morgenstern, Alan Krupnick, Ruth Greenspan Bell, Xuehua Zhang USEPA: Joe Kruger CRAES: Wang Jinnan, Cao Dong, Yang Jintian Others: Bob Anderson, Dan Millison, Stainer Larssen	1. Established good working relationship with people in Shanxi and Taiyuan through meeting with Shanxi and Taiyuan government agencies. 2. Developed a sound understanding of the current environmental management situation in Shanxi through meeting with local agencies and visiting enterprises.
May 14–18, 2001	RFF: Xuehua Zhang USEPA: Melanie Dean, Jeremy Schreifels CRAES: Cao Dong, Yang Jintian Others: Bob Anderson	1. Trained Shanxi and Taiyuan participants to gain a sound understanding of emission trading programs in general and particularly in the United States. 2. Sought comments and suggestions on the design elements and demonstration of SO_2 emission trading program for Taiyuan proposed by RFF. 3. Reached an initial agreement on general principles for the design and demonstration of an SO_2 emissions trading program in Taiyuan.

Dates	Participating team members	Major activities
July 9–13, 2001	RFF: Dick Morgenstern, Xuehua Zhang USEPA: Stephanie Benkovic, Joe Kruger CRAES: Wang Jinnan, Cao Dong	1. Reviewed the draft inception report and addressed the key concerns in designing a workable SO_2 emissions trading demonstration program in Taiyuan. 2. Shanxi, Taiyuan, and ADB agreed on the design elements and demonstration of the program as well as the one-year demonstration work plan.
September 11–14, 2001	RFF: Xuehua Zhang CRAES: Cao Dong, Yang Jintian	Conducted a survey on the 26 participating enterprises. The survey is designed to gain a thorough understanding of their SO_2 emissions conditions and reduction plans in order to come up a feasible allowance allocation plan.
October 9–12, 2001	RFF: Dick Morgenstern, Xuehua Zhang CRAES: Cao Dong, Yang Jintian	Discussed the proposed SO_2 allowance allocation with 26 participating enterprises and TEPB. The allocation plan was modified and finalized between TEPB and enterprises afterward.
December 17–20, 2001	RFF: Dick Morgenstern, Xuehua Zhang CRAES: Wang Jinnan, Cao Dong, Yang Jintian USEPA: Jeremy Schreifels	1. USEPA conducted training on emissions monitoring and allowance tracking. The participants were TEPB and enterprise representatives. 2. The RFF team, TEPB, and Taiyuan Legal Bureau discussed the draft regulation and implementation guidance document. 3. Follow-up plans for the next three months: a. CRAES and TEPB will revise and finalize the regulation and implementation guidance. The regulation is anticipated to be issued by Taiyuan City Government in March 2002 b. RFF and USEPA will develop a new software for tracking and verifying emissions and will design and organize a series of training sessions on monitoring, tracking, and operation of SO_2 emissions trading for participating enterprises and TEPB.
January 22–23, 2002	CRAES: Wang Jinnan, Cao Dong, Yang Jintian	The team discussed and revised the Administrative Regulation and drafted the Explanation of the Regulation.
April 9–12, 2002	RFF: Dick Morgenstern, Xuehua Zhang USEPA: Joe Kruger, Jeremy Schreifels CRAES: Wang Jinnan, Yang Jintian, Cao Dong	1. Reviewed the progress of the demonstration project since it was formally initiated in July 2001. 2. Presented and discussed the draft midterm report submitted by the RFF team. 3. Presented and discussed the demonstrations of emissions and allowance tracking systems developed by RFF and US EPA.
May 15–17, 2002	CRAES: Cao Dong Others: Bob Anderson	1. Visited six enterprises to provide further analysis of the potential cost savings to enterprises. 2. Held discussion with Taiyuan EPB and Shanxi Planning Commission to revise the midterm report. 3. Drafted the implementation guidance document.
June 10–12, 2002	RFF: Dick Morgenstern, Xuehua Zhang CRAES: Yang Jintian USEPA: Jeremy Schreifels Others: Bob Anderson	1. Conducted a two-day training workshop on enterprise managers, Taiyuan EPB, and Shanxi EPB. The workshop involved U.S. SO_2 emissions trading experience, emissions and allowance tracking system, and emissions trading interactive simulation. 2. Reviewed and revised the midterm report.

Dates	Participating team members	Major activities
September 6–12, 2002	RFF: Xuehua Zhang, Shawei Chen CRAES: Cao Dong USEPA: Jeremy Schreifels	1. Reviewed and revised the ETS software. 2. Conducted a one-day training workshop on ETS software to participating enterprises. 3. Demonstrated the ATS software. 4. Discussed the study tour to U.S. in 2003.
November 7–14, 2002	RFF: Ruth Greenspan Bell, Shawei Chen CRAES: Cao Dong USEPA: Jeremy Schreifels Others: Bob Anderson	1. Went over the regulation to get a better understanding of it and discuss some issues of concern. 2. Went over the procedure document for enterprises to implement the emissions trading. 3. Went over the procedure document for TEPB to implement the emissions trading. 4. Discussed enforcement and compliance issues of the trading program. 5. Finalized the ETS software. 6. Presented the revised ATS software based on September discussion. 7. Presented a quantitative example of a trade between two enterprises.
December 16–18, 2002	CRAES: Wang Jinan, Cao Dong USEPA: Jeremy Schreifels	1. Trained EPB staff on the usage of ATS. 2. Discussed the design issues of the emissions trading program. 3. Tested procedures and systems for the operation of the emissions trading program. 4. Conducted test trade among four selected enterprises.
September 1, 2003	RFF: Dick Morgenstern Shawei Chen ADB: Dan Millison CRAES: Yang Jintian Cao Dong USEPA: Jeremy Schreifels	1. Reviewed the draft final report, sought comments and suggestions on the revision of the final report. 2. Went over budget and expenditure of the project, and discussed future work.

* RFF: Resources for the Future; USEPA: United States Environmental Protection Agency; CRAES: Chinese Research Academy for Environmental Science; ADB: Asian Development Bank.

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APPENDIX 2

The Health Benefits of Reducing SO_2 Emissions in Taiyuan

The current policy goal in Taiyuan is to reduce ambient SO_2 concentrations from current levels (approximately 200 μ/m^3) to meet the Class II standards (60 μ/m^3). Doing so is likely to provide large benefits to the health of the city's population, according to health benefits analyses performed elsewhere in China and throughout the world. This appendix develops quantitative estimates of these benefits.

According to a study done for the ADB (HIID 2000), reducing annual average SO_2 emissions in Tongchuan, Shaanxi Province, from 228 μ/m^3 to the Class II standard averts 74 to 347 deaths, depending on the relationship assumed between SO_2 concentrations and mortality. This city has a much smaller population (436,000) than Taiyuan (3 million in the urban plus county areas), and the nonaccidental mortality rate for Tongchuan (440/100,000) is somewhat larger than for Taiyuan (417/100,000). Assuming that deaths averted would be proportional to these differences and the drop in SO_2 concentrations needed to meet the standard, Taiyuan could avert between 402 and 1,886 deaths annually by meeting its Class II standards, as measured from the current baseline concentration of 200 μ/m^3.

There are many uncertainties embodied in such an estimate, of course. The first concerns the pollution measures used. Analyses of the health benefits of pollution control in regions throughout the world have generally focused on those arising from reductions in various forms of particulate matter and SO_2 concentrations. These studies rarely include both SO_2 and particulates because SO_2 converts to sulfates in the presence of ammonia, and sulfates are particulates in the 1-micron diameter range. Thus, particulate concentrations and SO_2 concentrations usually move in concert, making it problematic to distinguish their separate effects on health in epidemiological studies.

The foregoing estimates of mortality effects are based on SO_2 concentrations and so are directly relevant to the Taiyuan case. Nevertheless, to the extent that particulate concentrations act independently of SO_2 concentrations on health—and there are many reasons for thinking there is some independence—or if these substances act synergistically, then the foregoing estimates of death averted would be too low.

The second uncertainty concerns the concentration-response (C-R) functions. HIID relied on two studies of the effect of daily SO_2 concentrations on daily mortality rates—one using data from Beijing, another conducted in Shenyang. Both are published; both appear to be of reasonable quality. Because the norm in secondary health benefits studies conducted in developing countries is to use C-R functions from the United States or other developed countries, the HIID estimates may be viewed as more applicable and reliable on this point than most such estimates arising from secondary studies. Nevertheless, the wide range of estimates from these two studies do not even reflect statistical confidence intervals and thus suggest that C-R model uncertainties are very high.

More importantly, the methodologies used by these two epidemiological studies, while state-of-the-art for time-series studies, are widely regarded as seriously underestimating total benefits of air quality improvements. The reason is that the so-called prospective studies (Pope et al.; Dockery et al.), which follow the mortality experience of a group of individuals for many years, capture effects of pollution both episodically and over the long term, whereas the daily studies capture only the episodic effects. The generally accepted mortality-risk coefficient (the percentage reduction in the mortality rate per 10 μ/m^3 PM10—see below) is about 0.3, and the same statistics for the daily studies range between 0.05 and 0.1, depending on the city.

The complicating factor in this argument, however, is that the prospective studies do not generally find significant effects of SO_2 on health in models where particulate measures are present. Because SO_2 contributes to sulfates, this negative finding does not in any way mean that SO_2 emissions have no effect on health. It is simply not possible to estimate by how much the health improvements of reducing SO_2 might be underestimated using only the daily studies.

Third, the daily studies cover deaths at all ages. There is considerable evidence that older people (those over 65) and the very young (under 1) are more at risk from air pollution than people in other age groups. The APHEA series of studies found lower mortality effects on the population living in several Eastern European cities, a finding partly explained by the lack of people old enough to be seriously affected by air pollution. The reigning hypothesis is that such people have already died from other causes in these countries, reducing the pool of individuals sensitive to air pollution. At the same time, effects for cities such as Mexico City appear to be not much different than in developing countries, where the older population is more prevalent. This occurs because the high birth rate in Mexico City effectively increases the pool of sensitive individuals. Thus, on net, the lack of older individuals and the dearth of younger ones cancel out.

In Taiyuan, 7% of the population in 2000 consisted of people over 65, compared with 13% in the United States. This difference partly accounts for the far lower mortality rate in China than in the United States (417 versus 800 per 100,000). It also may mean that the pollution-induced mortality effects seen in China should be lower, other things being equal, than in the United States. Without data on the population share of those under one-year-old for Taiyuan, the effect of differences in this age group on mortality rates cannot be assessed.

A host of other uncertainties could affect these estimates. First, Taiyuan could have very different conditions in health status, age distribution, pollution composition, and other factors that would affect the transfer of the SO_2 concentration-response relationships from Beijing and Shenyang to Taiyuan. Since these studies encompass such a large range, this effect is likely to be minimal but could be underestimated in Taiyuan, to the extent that coke oven and other coal-burning activities raise exposure to benzene and other carcinogens. Second, just because the four monitoring stations in Taiyuan obtain pollution readings does not mean that the population of this city will be exposed to those levels of pollution. Some of the readings are from stations very close to polluting sources; others may reflect too much or not enough of prevailing wind conditions vis-â-vis source locations or commuting patterns. Third, we have not addressed the effects of SO_2 on morbidity. If SO_2 affects mortality (either directly or indirectly through sulfates), then it should surely affect morbidity. In the literature, various studies find significant effects of particulate exposures on morbidity endpoints (U.S. EPA 1999), including effects specifically linked to sulfate concentrations (Burtraw et al. 1998). The list of endpoints includes

the probability of developing a case of chronic respiratory disease; the probability of experiencing a hospital visit or an emergency room visit; a restricted activity day; and a symptom day. Clearly, reductions in measures of these endpoints for a given pollution reduction are very large compared with the reduction in deaths averted. The last issue involves the likely size of the economic benefits from these health improvements. Because pollution reductions are costly, it is incumbent upon society to compare these costs with the benefits expected to be realized from this investment. Economists have developed a variety of techniques to estimate individuals' willingness to pay (WTP) for health improvements. Without going into this large literature, the WTP for mortality risk reductions is generally thought to be in the range of $500 annually for a 1-in-10,000 reduction in risk of death annually, or $5 million per death averted (dividing the $500 by the 1-in-10,000 yields the "value of a statistical life," or VSL). The morbidity benefits are much lower, with many U.S. studies finding that the morbidity benefits, in monetary terms, generally make up less than 20% of the total benefits, because values used to put a "price" on mortality risk reductions are generally so large.

For estimating Taiyuan's monetary benefits, there are several considerations. The main one is that incomes are so much lower in Taiyuan than in the United States that it would not be surprising to find that the willingness of the Taiyuan population to pay for risk reductions would be far lower than in the United States. Analysts therefore generally adjust WTP estimates for income differences where in-country studies are not available to make such estimates directly. The HIID study presented adjusted estimates of the WTP for mortality risk reductions they estimated for Shaanxi Province. They started with a VSL of $3 million, scaled down proportionally for income differences and corrected for differences in purchasing power parity, to arrive at a VSL of 2.3 million yuan. Correcting this estimate for differences in GDP per capita between Shaanxi and Shanxi Provinces, we arrive at annual mortality-related benefits of meeting the Class II SO_2 standard in Taiyuan of 925 million RMB to 4.3 billion RMB annually. Some studies find that preferences for mortality risk improvements are not that sensitive to income, making proportional income adjustments too large. Using a less dramatic income adjustment would only raise these benefit estimates.

■ ■ ■

APPENDIX 3

Commentary on Enforcement of the Air Act

The PRC has had considerable difficulty implementing and ensuring compliance with its environmental requirements. This section examines the tools for achieving compliance and enforcement, which are essential parts of an effective environmental management program. It notes that the PRC's capacity to implement a successful major SO_2 reductions program—using either conventional approaches or emissions trading—should be considered in the context of difficulties in its overall compliance and enforcement mechanisms.

Basic principles of legal liability—compliance and enforcement—are set out in Chapter VI of the Air Act. Some of the critical provisions, particularly those from the 2000 amendments that improve responsibilities for inspection and monitoring and develop penalties for falsifying data or refusing inspections, are noted below.

Article 5 states that "all units and persons have the duty and obligation [to protect] the atmosphere environment and are entitled to expose and file charges against any unit or person which causes pollution to the atmospheric environment" *(emphasis added).*[1]

Article 21, added by the 2000 revisions to the Air Act, authorizes on-site inspection of pollution sources by government authorities and requires all inspected units to report "their real information" and provide necessary materials to inspectors.

Article 46 provides authority for warnings or fines for refusal to report or submission of a false report, the refusal of an unannounced inspection, deception or fraudulence when being inspected, or failure to pay fees for excessive discharges.

Although the new legal provisions represent a fairly explicit recognition of the need for stronger inspection, oversight, and enforcement, they have not yet been set fully into place with implementing sublaws or regulations, or tested.

The Air Act also establishes basic requirements for the reporting of both pollutant quantities and concentrations, and for providing technical data and information. As in the case of regulatory standards, the Air Act itself does not spell out what these provisions mean or how they are to be implemented; rather, the act leaves it to provincial and local environmental authorities to issue regulations on the specifics of these requirements.

To date, the levy system has been a critical part of the PRC's regulatory and compliance program. Although the levy system could be considered to be a form of enforcement tool, at current levels it is best suited to collecting revenue, which in turn is used to support environmental protection bureaus (EPBs) and some environmental improvement projects.[2] Thus, the levy acts as a proxy for permit enforcement, more like a collection system, but does not in fact constitute direct permit enforcement.[3] It was not surprising to learn that Taiyuan officials were prin-

cipally motivated to collect fees and fines relating to pollution levels and only secondarily to bring other types of enforcement cases, such as responding to citizen complaints in neighborhoods and communities.[4]

The concern that the fees and fines not only are insufficient to motivate enterprises to modify their polluting behavior, but also constitute to some degree a pay-to-pollute policy, was effectively recognized in the new Air Act. The new law introduces changes in the way the levy affects environmental enforcement. Previously, enterprises could pollute in excess of national standards, provided they paid fees. Under the new Air Act, Article 48, Chapter 6, this practice is expected to change, once implementing regulations are passed. If emissions exceed the discharge standard, they must be reduced within a specified deadline, and at the same time, the polluter must pay a fine (between 10,000 and 100,000 RMB) to the provincial or local EPB.[5]

One important goal for the PRC would be to develop a more complete enforcement "toolbox".[6] The PRC currently imposes serious potential criminal penalties for violation of environmental requirements. Typically, however, criminal penalties are, as in any society, the "nuclear bomb in the back pocket." Generally, the criminal code does not provide sufficient flexibility for enhancing compliance, as opposed to punishing bad actors.

Most important, since the economy is still dominated by state-owned enterprises (particularly in the sectors of concern in this project), the line between the regulated community and the regulator is still fuzzy, and inherent conflicts of interest between economic and environmental goals persist; this is the "double burden" that can be seen in all such economies. Further, we were unable to determine whether levies and fines are actually taken out of profits or still constitute some sort of soft budget line, which would definitely undercut their effectiveness as a compliance tool.

■ ■ ■

1 Positive recognition and "rewards" for high-achieving units and persons are authorized by Article 8.

2 National policy is changing this arrangement. Soon, all PLS receipts will pass directly to the municipal budget and the environmental protection bureaus will receive funding as a budget appropriation, severing the link between levy collections and bureau budgeting.

3 We were told that resources for additional enforcement were scarce.

4 The "letters and visits" (*xinfang*) method by which citizens notify officials of construction noise, dust, and other problems is active in Taiyuan. See also W.P. Alford and Yuanyuan Shen, "The Limits of the Law in Addressing China's Environmental Dilemma," in *Energizing China: Reconciling Environmental Protection and Economic Growth*, Harvard University Press, 1998, 420. The process in response to complaints is to send TEPB employees out to take measurements using. mobile monitoring gear, binoculars, and noise readers. The remedies are to: (1) ask for corrections; (2) close facilities; or (3) impose fines. The availability of the first remedy raises questions why corrections can't be used in other circumstances. Two levels of appeal are available to enterprises or others who dispute the findings or the remedy. The hierarchy of appeals includes administrative appeals, appeals to TEPB, to the province, and then to a court.

5 See "Key Aspects of the 2000 Amendments to the Air Pollution Prevention and Control Law of the People's Republic of China, Briefing for Corporate Counsel and EHS Managers," Beveridge & Diamond, P.C., 2001 (available at http://www.bdlaw.com/publications.asp).

6 A discussion of available environmental policy and enforcement tools as they are used in the United States is found in U.S. Congress, Office of Technology Assessment, Environmental Policy Tools: A User's Guide, OTA-ENV-634, Washington, DC, U.S. Government Printing Office, September 1995.

APPENDIX 4

Legal Issues Surrounding the Implementation of an Emissions Trading System in Taiyuan

Bulleted below are summaries of provisions of the Law of the People's Republic of China on Atmospheric Pollution Prevention and Control that appear to be most important for the purposes of this project.

- In Article 3, the national government is required to take measures to reduce the total amount of pollution. Local government is made responsible for local air quality and for developing a plan and taking measures to bring the local air quality to the national standard.
- Article 6 gives responsibility to the Department for Environmental Protection of the State Council to set national standards for atmospheric environmental quality. In the event that no national standard is set, the people's government of a province or of certain cities may establish a local standard, which it submits "for the record" to the relevant State Council department.
- Article 7 refers to the emissions standard and allows local or provincial governments to enact standards more stringent than the national standard.
- Article 8 directs the national government to take economic and technical measures and policies that are propitious to air pollution control.
- Article 12 establishes an emissions reporting system. Reporting is the responsibility of polluting units. Reports are also required concerning treatment facilities and their operating conditions.
- Article 13 says that the pollutant discharge concentration of all pollutants emitted to air cannot exceed the state and local emissions standards.
- Article 14 establishes the levy system regarding types and quantity of pollutants. It is the first time that the levy has been set according to the amount emitted. The levy must be turned in to the government and used for air pollution control according to relevant regulations of the State Council; it cannot be used for any other purpose, and the use must be supervised by the audit department.
- Article 15 establishes the Total Amount Control (TAC) and the legal basis for a permit system. All areas that could not reach the air quality standard and Two Control Zone (i.e., acid rain and SO_2) authorized by the State Council are to be designated as air pollution areas. Taiyuan is among these areas. The State Council is to formulate detailed regulations, which are expected to have some language about emissions trading. In the Air Pollution Total Amount Control reas, local governments have the authority to check and ratify the TAC of the enterprises and institutions and issue air emissions permits according to conditions and processes defined by the State Council. They are to do this consistent with principles of openness, fairness, and equity.

- Chapter III of the Air Act has special provisions for the prevention and control of atmospheric pollution caused by coal burning. These provisions tend to be very prescriptive. At the same time, they lack specifics. For example, they require quality standards for boilers; directions for urban planning and the development of central hearing; improvement of urban fuels; the promotion of coal washing and dressing; substitutions for raw coal burning; and the requirement of desulfurization and dust-removing facilities for generators in designated acid rain control areas.[1] Article 48 indicates that those facilities that exceed national and local standards have a limited time to bring the emissions under control and must pay fines.

In sum, although on the national level there is no direct authority for trading, Chinese officials believe that there is indirect support because the law authorizes two key elements of trading—TAC and the permit system—especially in the Two Control Zone areas, which include Taiyuan.

The difficulty with these provisions from the perspective of a U.S. lawyer is that many of them do not yet have implementing regulations that would clarify to the regulated community what they mean and how compliance is to take place.[2] Thus, they do not specifically state how the requirements of the Air Act are to be achieved. This concern about the lack of specifics was shared by Taiyuan regulators and environmental enforcers, in interviews in Taiyuan. However, some Chinese officials interviewed believe that the failure in the national law to have specifics could be positive, as it leaves greater opportunity for the local government to establish its own, more detailed, laws. The chief responsibility of the EPBs and environmental protection offices is to enforce laws and implement policies designed by SEPA and to assist in drafting local regulations (including local laws and implementation regulations) to supplement central ones. Those local regulations have to be approved by provincial or municipal people's congresses.

Although local regulations have not yet been written and the law lacks some specifics, the new Air Act is having some practical effect, and it is clear that local officials are seriously interested in reducing SO_2 emissions.

Taiyuan-Level Legal Authority

Taiyuan City has existing legal authority for emissions trading in the form of an administrative decree,[3] enacted in October 1998 as part of a rule for Total Emissions Control for Air Pollution. In Chapter Three — Permits Transfer — the decree authorizes trading pollution rights so long as all parties to the transaction also meet their "emissions concentration standards." Units can either bank or trade. Trades must be supervised and approved by the local environmental protection bureau.

This decree has not yet been supplemented by implementing regulations. We were told that an effort to write implementing regulations would require political support from senior officials.[4] With such support, Taiyuan Environmental Protection Bureau officials estimated, it would take approximately a year to put regulations into place.

We do not think that the lack of implementing regulations should be considered a barrier to doing a *demonstration or pilot* emissions trading project in Taiyuan, but implementing regulations would be helpful to institutionalize and generalize the results of the demonstration project. In addition, according to the Chinese members of the project team, the pilot trading will require a regulation, decree, circular, or some other way to describe the detailed rules for trading.

Experiment Authority

One legal basis for an SO_2 emissions trading demonstration could be the authority to engage in environmental experiments. The Chinese government has a long history of engaging in "pilots" or "experiments" to try out new ways of managing environmental problems.[5] Pilot projects help the Chinese government test new regulatory methods, increase Chinese experience, and learn how to extend new regulatory ideas for wider application in the context of diverse Chinese conditions. Successful experiments are then institutionalized and used throughout China.

At various points in our interviews, we were informed that experiments were authorized by law, but when we probed to determine the specific legal provisions, we were told that the authority was rooted in longstanding common practices of Chinese policymaking, rather than law. It is probably fair to assume that convincing the State Environmental Protection Administration (SEPA) of the merits of an experiment is sufficient. Several officials we spoke with were of the opinion that the Taiyuan City government has the authority to engage in a demonstration without any formal permit from SEPA.[6] Whatever the source, experiments seem to be an established procedure in Chinese environmental practice. This customary authority might be a basis for an SO_2 emissions trading demonstration project.

Five-Year Plans, National Programs, and their Roles in Setting Regulatory Standards and Goals

The Chinese government has given an extremely high official priority to the environment (elevating environment to a "fundamental state policy"), and local officials and enterprises are mindful of this responsibility. In part because of Chinese political culture and traditions,[7] in part because the law has very general provisions that have not been spelled out by more detailed regulations, national programs (such as the current one that gives high priority to meeting emissions standards by the end of 2000) and five-year plans have an equal, if not greater, role in the process of controlling air emissions.

National programs are directed from the very top of Chinese government, and national policy attention is paid to the identified issues. This way of addressing pressing issues is more familiar and comfortable for Chinese officials than is law, in which they have less experience and fewer experts.[8]

In this regard, it is important to note the program called One Control and Two Reach Standard (Yi Kong Shuang Da Biao). "One Control" refers to Total Emissions Control. This originated in the Ninth Five-Year Plan (1995–2000). On September 3, 1996, the State Council issued a document to SEPA, the State Development and Planning Commission (SDPC), and the State Economics and Trade Commission (SETC) entitled "State Council Reply to the National Ninth Five-Year Plan and 2010 Prospective Target for Environmental Protection." On November 26, 1996, the above three government agencies sent a circular to every province, jurisdiction, city, and other government agencies at the same level to ask them to implement the plan.[9]

The Two Reach Standard began in the State Council Decision to Some Issues of Environment Protection, promulgated in 1996. In this decision, the State Council required all industrial pollution sources to meet the national or local emissions concentration standards, and further required certain cities to meet the relevant environmental quality standard. On November 4, 1998, SEPA issued a detailed working plan for the Two Reach Standard and provided detailed requirements to the governments at different levels.

To realize the goals set out in One Control and Two Reach Standard, local governments have depended heavily on "pollution control within the deadline"—one of the Chinese eight systems (or environmental policy programs for environmental management).[10] The penalty for failure to meet the standard by the deadline was forcible closure.[11]

The details of the Tenth Five-Year Plan are set out in Chapter Two of this report.

Limits of Legal Analysis: Informal Methods of Reconciling Legal and Economic Goals

On numerous occasions in our interviews, we heard about conflicts between legal requirements and the economic reality connected with compliance.[12] In the literature, this is called the double-burden requirement because economic development and environmental protection come into conflict.[13] Although there is increasing understanding of the importance of sustainable development, especially among the government officials, X. Zhang's survey and other research indicate the significance of city governments' intervention in the administrative enforcement work of prefecture EPBs, presumably to put production goals ahead of environmental objectives and to protect enterprises.[14]

One example involved a Taiyuan City requirement that had several parts:

- Restaurants, food stands, and boilers for tea in specified parts of the city are to use clean technology like gas, electricity, and oil by December 31, 1999.
- Citywide, the electricity plant is to use coal of less than 1% sulfur content and must control dust to under 10%. Also, boilers that are used for production and heating must gradually switch to "excellent coal"; boilers small than 1 ton must use briquettes.
- New boilers larger than 4 tons must install sulfur and dust removal. The existing boilers of this same size must add sulfur removal. The modifications must be made before the end of 2000.
- In specified areas of the city, the entertainment and food industry and bathhouses are not to build any new boilers that require coal. Boilers smaller than 2 tons must be modified to use gas, electricity, or oil in place of coal. In the period before they complete modification, they must use briquettes. Boilers larger than 2 tons must use clean fuel (including refined coal).

The Taiyuan Railroad Bureau, responsible for providing heating to the workers in its units, found this requirement imposed unacceptable costs and it was therefore not followed.[15] What was opaque was whether this result was a negotiated solution between the state-owned railroad authority and Taiyuan City and whether and how it was memorialized.[16]

1 For example, in Article 24, the state "promotes" coal washing and dressing to reduce sulfur content and "restricts" the mining of high-sulfur and high-ash coal. It requires mines that dig such coal to install coal washing and dressing facilities.

2 See X. Zhang, *Institutional Constraints on China's Environmental Enforcement: A Perspective of Local EPB Personnel*, M.A. thesis, Western Washington University, March 2001 draft, 31. Based on a survey conducted in 1999, environmental laws and regulations are "not concrete enough" and "impractical and unenforceable." X. Zhang indicates that the responsibility for this lies with local government, which "is the body responsible for making the detailed enforcement rules and measurements to carry out national regulations." Chapter VI of the Air Act, discussed below, does set out compliance responsibilities and penalties for failure to meet them.

3 Item 19 makes pollution discharge permits within the Total Emissions Control tradable so long as the discharge standards are met and the trading is supervised and "instructed" by the environmental protection administrative bodies. Item 20 allows units to either bank their extra emissions credits or transfer them to other units so long as the actual

amount is lower than the permit level. A preference is stated for trading among "the same type of functioning area and pollutants." Item 21 addresses requests for new, expansion, or modification projects. If the applying enterprises or the [geographic] area present a situation in which current total emissions control goals and permits are already exceeded, "in general," such expansion or new development is not allowed. However, if the development "is really needed," the areas and enterprises have to obtain additional emissions permits through trading, except for projects that have high energy consumption or cause heavy pollution. Item 22 requires that purchase and sales of permits be done through a written contract, which must be reviewed and approved by the local environmental protection bureau, and a new emissions permit issued. Emissions trading does not excuse units from their other environmental protection obligations (Item 23).

4 The previous work on the decree was driven by an official who subsequently died, and the project had to win new political backing. A Chinese member of the project team believes that implementing rules will not be difficult to write, but that an institutionalized trading program, following the demonstration, will need support from "high levels"—in this case, the general director of TEPB.

5 Experimentation resulted in the license system for pollutant discharge, the water discharge permit system, and the levy system. A more complete list of experiments is found in T. Panayotou, "The Effectiveness and Efficiency of Environmental Policy in China," in *Energizing China: Reconciling Environmental Protection and Economic Growth*, Harvard University Press, 1998, 434–36.

6 The Chinese members of the project team are somewhat less concerned about finding a clear legal basis for a demonstration than are the U.S. members, as the role of law in decision processes in China is in an early formative stage. See, for example, *The New York Times*, "China's Inner Circle Reveals Big Unrest," by Erik Eckhold, June 3, 2001, reporting recommendations from a top party research group including a plea for speedy reforms within the party and government, such as strengthening the legal system (available at www.nytimes.com/2001/06/03/world/03CHIN.html).

7 This legal review recognizes that China is in the early stages of instituting a society based on the rule of law, in contrast to its long history in which moral precept and local custom have been the basis for resolving many problems that other societies have addressed through public, positive law. See, for example, W.P. Alford and Yuanyuan Shen, "The Limits of the Law in Addressing China's Environmental Dilemma," in *Energizing China: Reconciling Environmental Protection and Economic Growth*, Harvard University Press, 1998. It is still the case that legal requirements require political backup and/or commitment.

8 X. Zhang's survey (*Institutional Constraints on China's Environmental Enforcement: A Perspective of Local EPB Personnel*, M.A. thesis, Western Washington University, March 2001) illustrates this problem. Only 37% of EPBs have law specialists or employ legal advisers. Zhang suggests the need for further study on whether those legal specialists understand the technical context of environmental laws, regulations, and standards (p. 35).

9 In China, the law is not self-executing. Therefore, the regulations of different sectors and documents, decisions, and circulars issued by the different levels of government play an important role in guiding implementation.

10 See Sinkule and Ortolano (1995).

11 "Pollution control within the deadline" was evaluated poorly among the eight programs reviewed by Sinkule and Ortolano (1995) and by other researchers. X. Zhang's survey, conducted in 1999 (*Institutional Constraints on China's Environmental Enforcement: A Perspective of Local EPB Personnel*, M.A. thesis, Western Washington University, March 2001) found that local EPB staff ranked it the second most effective policy program. Only the levy system was ranked higher.

12 These conflicts are common where most if not all of industry continues to be government-owned.

13 See X. Zhang, *Institutional Constraints on China's Environmental Enforcement: A Perspective of Local EPB Personnel*, M.A. thesis, Western Washington University, March 2001, and studies cited therein (at p. 19). A survey conducted by Zhang across China found that half of the respondents from local EPBs believed that local government—"local protectionism"—was the fundamental enforcement obstacle (at p. 30).

14 *Ibid*, 32.

15 Note also that Article 25 of the Air Act requires large and medium-sized cities to create plans to make civilian stoves replace direct burning of raw coal.

16 The ultimate "solution" to this conflict is apparently going to be found in the requirement of various enterprises (e.g., the railroad authority's heating systems) to close down boilers and hook up with the city's central hearing system. This requirement—and the related energy efficiency—could be improved by concurrently requiring apartments to install specific thermostats and individual metering to encourage consumer conservation.

APPENDIX 5

Responsibilities of Other Offices in Taiyuan Environmental Protection Bureau

Other offices in TEPB that are not included in the text are as follows:

The Development and Supervision Division implements national and provincial laws and regulations and policies concerning development and construction projects; studies local regulations and supervises their implementation; and approves environmental impact assessments and implementation of the Three Simultaneous system. The division supervises the pollution control and environmental management in town and village enterprises; coordinates with the State Environmental Protection Administration (SEPA) at higher levels regarding environmental management of radiation within the domain; coordinates with SEPA at higher levels to implement and manage the pollution from development of radioactive mineral resources; and is responsible for emergency response to radiation in the environment.

The Water Pollution Control Division is responsible for management of municipal water pollution, solid waste, and hazardous waste and drafts regulations and management approaches in wastewater pollution control and solid waste and hazardous waste pollution control. The division also examines municipal water pollution, solid waste and hazardous waste pollution control within a prescribed period and the concentrated treatment approach, the objective-responsibility system in protecting environment, and the comprehensive renovation of the city. It is also in charge of the registration of reporting water pollution and solid waste and the implementation of the emissions permission system; responsible for putting forward the suggestion on year plan of control projects, reviewing the proposal and implementing supervision; and fulfills other work assigned by the director.

The Nature and Ecological Protection Division supervises the use of natural resources that may affect the natural environment, the restoration of ecosystems, and the reconstruction of the natural environment. The division supervises environmental protection in nature reserves; guides and supervises the reclamation of mines, the protection of biodiversity, the protection of wildlife and plants, the protection of wetlands, and the prevention of desertification; manages the safety of biotechnology; supervises the environmental protection in rural areas; and guides the building of the city ecosystem demonstration district and eco-agriculture.

The Technological Standards Division organizes environmental research in the city; develops and promotes environmentally sound technologies; assists SEPA in evaluating local environmental quality standards, emissions standards, pollution control standards, and environmentally sound technology regulations; and implements the environmental standards of the state and the province. The division also organizes and applies for environmental protection projects and manages the achievements in environmental protection in the city; carries out the preliminary review on enterprises that apply for certification of environmental labeling; and guides and promotes the development of the environmental industry.

APPENDIX 6

Design Elements for an SO_2 Emissions Trading Program in Taiyuan

Design Issues	Design Options	Questions, Issues, and Data *Addressing these questions will help policymakers choose appropriate design options for an emissions trading program. This column may be used for notes, etc.*
Part I. Policy-Level Design Elements		
1. Environmental Goal: An emissions cap should reflect the emissions reductions needed to achieve environmental goals. Other factors, including control costs and political issues, may factor into consideration as well.		
Emissions Level for Cap		
Maximum emissions limit or cap for the trading program	A. The SO_2 emissions cap is _____ tons per year, derived from the Total Emissions Control (TEC) established for each source to meet Tenth Five-Year Plan goals. B. The SO_2 emissions cap is _____ tons per year, derived from the TEC established for each source to meet the Taiyuan Tenth Five-Year Plan goals. C. The SO_2 emissions cap is set at a level that allows Taiyuan to attain the Class II air quality standard. D. Attempt to measure and integrate fugitive emissions into program in A or B or C. E. Include nonpermitted diffuse sources in A or B or C.	
Timing (Beginning Year, Target Year, and Phase-In)		
Timing of emissions reduction requirements	A. After the demonstration phase of the ADB project is over, a start date and compliance data are established. B. The compliance date reflects the goal in the Tenth Five-Year Plan and the Taiyuan mayor's plan—2005. C. Select another compliance date (e.g., coincident with the next five-year plan) sufficient to attain Class II standard. D. Consider whether a gradually declining cap should be put in place. E. Push deadlines in Tenth Five-Year Plan ahead to reflect cost-savings with emissions trading.	

Design Issues	Design Options	Questions, Issues, and Data
Capturing Environmental Impacts from Emissions Trading		
Environmental implications of using emissions trading	Consider establishing trading ratios or zones to take advantage of spatial differentiation of effects from different sources on population or on attainment of the Class II standard.	Are emissions reductions likely to occur where they are most needed? Are major emissions sources located "upwind" of environmental impact areas? Use source-receptor modeling for SO_2.
2. Scope and Applicability of Trading Program:		
Affected Sources		
Source categories to include in trading program	A. Include all 36 permitted enterprises. B. Include all electricity boilers and large industrial sources. C. Add direct heat and power D. Only sources in same "functional area" can trade with one another. E. Other options.	
Trading Area		
Geographic scope or area that the trading program covers	A. Program includes only Taiyuan City. B. Program includes surrounding counties (Greater Taiyuan). C. Begin planning to expand area to other cities in Shanxi Province.	
New Sources		
Incorporating new sources	A. Major new sources need to purchase allowances in the market to offset emissions. B. Major new sources receive allowances from a government setaside or ask the government to arrange trades. C. Major new sources need to purchase more allowances than one-for-one. D. Other options.	

Design Issues	Design Options	Questions, Issues, and Data
3. Allowance Distribution versus Auction or Sale: Allowances can be distributed to sources free of charge or can be sold for a fixed price or auctioned. Different methods of allowance distribution and sale are addressed in greater detail below in Part II.		
How sources obtain allowances (Other allowance issues, including definition and allocation methods, are addressed in Part II)	A. Allowances are sold at a predetermined fixed price. B. Allowances are auctioned. C. Allowances are distributed to sources free of charge D. A portion of allowances is distributed freely and the remainder auctioned. E. Other options.	Are additional revenue sources needed to administer the program? See Part II, Section 3, "interface with levy system," below. Who would sell allowances and how would the revenue be used? See Part II, Section 3, "interface with levy system," below.
Prices	A. Prices are initially set by the local EPB in consultation with sources, later determined in the market. B. Prices are set in the market.	
Relationship with discharge standards	A. Discharge standards are no longer necessary for participating firms. B. Enterprises must meet concentration standards, but not mass standards. C. Enterprises must meet mass standards.	
Banking—will sources will be allowed to save allowances for use in future compliance years?	A. Sources can use allowances for future years. B. Sources are not allowed to bank allowances, or limits are set on the amount of banking.	

Part II. Administrative Design Elements

1. Emissions Quantification, Reporting, and Verification: The integrity of an emissions trading system is critical. Everyone involved, including enterprises, the regulatory bodies, and the affected communities, must be confident that all parties are following the rules and living up to their obligations. Emissions measurement, reporting, and verification are fundamental, as they are to any effective pollution control program. Measurement methods must be able to quantify the total amount of emissions from each source so that compliance can be determined and so that tradable allowances can be created fairly for commerce. There should be a standard reporting format to ensure that the same information is collected from all sources. This facilitates verification and ensures fairness. Rapid collection, verification, and publication of data facilitate trading and cost reduction.

Emissions Quantification		
Standards for emissions measurement	A. Sources participating in the program use a standard emissions measurement technique that is validated annually by the local EPB. B. Sources participating in the program use continuous emissions monitors (CEMs). C. The local EPB also calculates emissions from fuel use and quality data for each enterprise as a rough check on reported emissions. D. Other options.	

Design Issues	Design Options	Questions, Issues, and Data
Emissions Reporting		
Reporting standards for emissions data	A. Emissions and other important data are reported quarterly by all sources in a standard format to the local EPB, which prepares a report for the provincial EPB. B. Examine options for electronic reporting.	
Verification		
Validating emissions data, including quality control checks of methods used and equipment (monitors)	A. Fill in based on answers to questions in next column. B. Use a project pilot or demonstration to experiment with [include] alternative methods for validating emissions data	Who currently validates source emissions data? How often? Annually? Are the checks done on site? Or are there data quality checks (more like a file review)? Are their results available at the source level? Who currently performs quality control checks on emissions data and how often? See also Section 3, "compliance," below

3. Allocations: Allowances are the currency of an emissions trading program. Allowances can be allocated in many ways as long as the total number of allowances allocated does not exceed the cap level.

Defining and Allocating Allowances		
Definition	A. One allowance is defined as an authorization to emit 1 ton SO_2	
Allowance distribution method (See policy question onwhether allowances are given to sources or sold.)	A. EPB distributes available allowances directly to sources using source-specific TEC. B. Provisions are established for granting allowances for diffuse sources and for fugitive sources. C. Other options.	
Allowance accounts	A. All affected sources have allowance accounts.	
Who can hold allowances	A. Only sources participating in the program can buy and sell allowances. B. Other options.	

Design Issues	Design Options	Questions, Issues, and Data
4. Legal Authority and Responsibility: The importance of compliance assurance and enforcement to an emissions trading system cannot be overstated. Carefully and clearly defined roles and responsibilities for government entities and affected sources ensures environmental integrity, as does public confidence that the system is being implemented in a fair and even-handed manner. There must be clear and realized penalties for failure to follow the rules. Chinese experience and institutional gaps—limited experience with market discipline, particularly in the sector of the government that regulates the environment (extended history of soft-budget constraints, free use of resources)—affect implementation capacity. Ideally, one entity should be responsible for administrating the overall program.		
Authority and Roles		
Program administration	To be determined.	Initiate open discussion of the "double-burden requirement" (informal resolution of conflicts between economic development and environmental protection) and how it can be resolved in the context of emissions trading to reduce city government intervention in favor of production goals ahead of environmental objectives. Involve EBP, Planning Commission, and participating enterprises to create buy-in and prevent circumvention. What are the resource requirements to administer the overall program? Who has the technical and financial ability to administer the program? What would be the role of other ministries and other levels of government, like the environmental protection bureaus? Would sources, the private sector, and the public have defined roles in the program? What would they be?
Legal framework within which emissions trading laws could be developed	A. Permits exchange regulation. B. Implementing regulations follow as part of the demonstration. C. Legal authority can be supplemented or replaced by well-functioning environmental responsibility system.	

Design Issues	Design Options	Questions, Issues, and Data
Compliance		
Procedure for compliance determination	A. Develop allowance tracking system as part of demonstration. B. Local EPB runs the emissions and allowance tracking systems. C. Establish a reconciliation period, after which compliance is determined by using data from the allowance tracking system and emissions tracking system for each source to ensure that all emissions are covered by allowances. D. Unannounced spot checks are followed by public announcements.	Develop methods to ensure against off-books deals.
Authority to enforce noncompliance at the source level	A. Local EPBs are responsible for tracking emissions for each source and enforcing noncompliance.(with the exception of power plants, which are the responsibility of the provincial EPB). B. Discuss alternatives to traditional enforcement and compliance. C. Personal responsibility through written contracts or agreements.(huanjing mubiao zeren zhi) (used to specify environmental targets in respective jurisdictions for a particular time period). D. Make contracts entirely or partially public, to build a level of public obligation and trust in emissions trading. E. Other options.	Develop methods consistent with Chinese experience for ensuring compliance.
Noncompliance penalty	A. The noncompliance penalty is set high enough to discourage noncompliance B. If a genuine penalty is not a realistic option, explore other options, such as personal responsibility contracts with salary or status, or public disclosure of performance failures as penalties for noncompliance . C. Examine other options with Chinese help.	What penalty level provides an incentive for sources to comply with the program? (Information on abatement costs would be helpful in determining an effective penalty level.) Work with Chinese enforcement authorities to develop a full "toolbox" of enforcement tools. Review alternatives to traditional enforcement tools. Determine whether current levy and fees are part of soft budget. Would enforcement penalties be added to the levy revenues?

Design Issues	Design Options	Questions, Issues, and Data
Interface with levy system	A. Reduce levy rates to insignificance. For EPB and other revenues, rely instead on surcharge on each allowance distributed. Put in place new noncompliance penalty system. B. Same as A, except levy system is used to collect fees for violating source cap (emissions exceed number of allowances held). C. Other options.	Need to break dependence of EPBs on levy collections.
5. Information Systems: Systems to manage emissions data and allowance activity reduce errors and facilitate operation of a trading program.		
Tracking Systems		
Emissions tracking	A. Local EPB receives emissions reports quarterly and prepares report for provincial EPB, which consolidates emissions reports for all participating sources. B. Other options.	
Allowance tracking	A. Allowance tracking system is developed as part of demonstration, provides an efficient means of monitoring compliance. B. Other options.	
Allowance transfers	A. The seller submits a form at any time indicating which allowances to move into which specific account. B. Both buyer and seller complete a form to indicate a transfer. C. Transfers can be completed electronically. D. Transfers can occur at any time. E. Other options.	Would both buyer and seller need to complete a form to indicate a transfer, or just a seller? Could transfers be completed electronically? Would transfers occur at any time or only during certain periods? What checks could ensure that appropriate allowances are transferred?

■ ■ ■

APPENDIX 7

Modeling SO_2 Concentrations in Taiyuan in 2005 for Selected Emissions Trading Scenarios

Referring to the Norwegian Institute for Air Research (NILU) tasks in this project according to the contract with RFF, and the correspondence on the air pollution modeling task of investigating the effects on the air pollution concentrations in Taiyuan of some proposed trading scenarios of SO_2 emissions, we hereby present the results of such calculations. The SO_2 situation in 2000 represents the base case. The scenarios have been defined by RFF: the baseline scenario for 2005 is defined by a 50% reduction of the SO_2 emissions from all point sources in the area. Three trading scenarios were defined, and the results of the calculations of the results of the base case and trading scenarios are presented.

The Model and the Dispersion Calculations

The calculations were carried out using the NILU-developed air quality management system AirQUIS (www.airquis.com). This system is at present installed at the Shanxi Environmental Information Centre of the Shanxi Environmental Protection Bureau (as well as in the three cities Taiyuan, Datong, and Yangquan).

The urban airshed dispersion model embedded in AirQUIS is the NILU-developed Eulerian grid model "EPISODE." The modeling system includes a meteorological preprocessor for calculating dispersion parameters based on meteorological observations, a wind field model ("MATHEW") for producing a spatially distributed wind field based upon meteo-observations in one or a few points, and a point source model (a segmented plume trajectory model "INPUFF") for improved treatment of the dispersion from tall stacks in Taiyuan.

The AirQUIS system also incorporates an emissions module giving the required emissions input to the dispersion calculations. The emissions inventory used in the present calculations were produced by Shanxi and Taiyuan authorities under the project, "Master Plan against Air Pollution in Shanxi Province," led by NILU. The SO_2 inventory includes 69 industries and 182 stacks with SO_2 emissions (details in Annex 2). Each stack is characterized by the data needed for dispersion calculations (height, diameter, exit velocity, etc.), to the extent they are known. The emissions inventory is currently being quality-assured. We know that the inventory used in the present calculations includes errors and is not 100% complete. However, we believe that most of the existing large sources are included in inventory, and that it is a sufficiently good basis for running sample calculations of the main effects of some trading scenarios.

Emissions vary with time (by hour, day, and month) from each stack, and there are modules embedded in AirQUIS to take care of such variations. However, detailed time variation information is not yet available and has thus not yet been included in the emissions database. The emissions are therefore kept constant for all hours of the calculation period.

The modeling area is 24 x 40 km, centering on downtown Taiyuan, shown in the maps in this report.

The SO_2 concentration calculations were carried out using meteorological data for November 2000. Calculations are done hour by hour for the entire month, for each of the 1 km2 grids of the entire model area, and statistical parameters are calculated from the resulting hourly fields of SO_2 concentrations.

The meteorological station is located in the valley bottom.

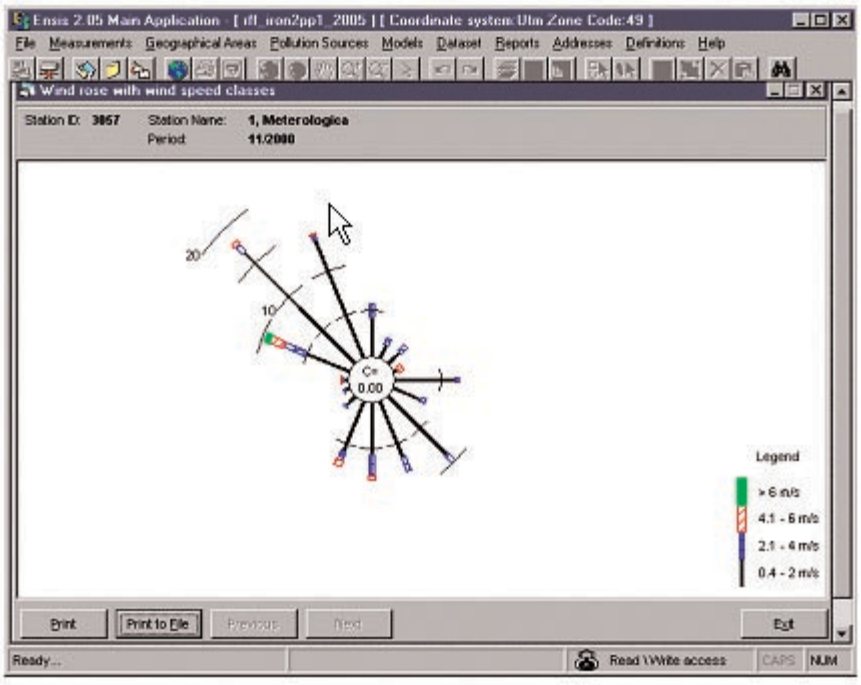
The windrose for November 2000 is shown in Figure 1. Two main wind directions stand out:

- Wind from the northwestern sector, centered on 315 degrees: about 43% of the time
- Wind from the southwestern sector, 130–210 degrees: about 32% of the time.

The northern sector dominates at night and the southern sector during daytime. Such diurnal wind patterns typically have large significance in dispersion calculations. However, in this case, where the emissions are considered uniform with time, since we lack time variation data, this diurnal wind pattern is of no consequence for the modeling results.

FIGURE 1.

Windrose for Taiyuan, November 2000



Trading Scenarios and Calculations

The scenarios are described in detail in Annex 1 but presented in brief:

1. ***Base case:*** Year 2000 SO_2 emissions within the modeling area.
   - Total emissions from 69 industrial plants with a total of 182 stacks: 150,565 tons/year (details in Annex 2).
   - Total emissions from area type sources: 29,247 tons/year.
2. ***Scenario 1 Baseline*:** 50% reduction of the point source SO_2 emissions from 2000 to 2005.
3. ***Training scenarios*.**

Table 1 gives an overview of the trading scenarios.

- Scenarios 2 and 3 are trades between Taiyuan Iron & Steel and Power Plant 1, both ways.
- Scenarios 4 and 5 are trades between Power Plant 1 and Power Plant 2, both ways.
- Scenario 6 is comparable to scenario 2 (with PP1 as seller), with an additional, smaller trade between two smaller companies.

Table 2 summarizes the stack and emissions data that are in our database, for the companies involved in the trading scenarios.

TABLE 1

Overview of Trading Scenarios

Trading scenarios	Power Plant 1	Power Plant 2	Taiyuan Iron & Steel Material Industry	Taiyuan Flameproof Materials Plant	Xinan Chemical	Amount (tons/year)
2	Seller		Buyer			10,000
3	Buyer		Seller			10,000
4	Seller	Buyer				10,000
5	Buyer	Seller				10,000
6	Seller		Buyer			10,000
				Seller	Buyer	2,912

TABLE 2

Stack and 2000 SO_2 Emissions Data

	Stacks	Stack Heights (meters)	Total Emissions (tons/year)
Power Plant 1	2	210	56,320
Power Plant 2	2	210–240	40,800
Taiyuan Iron & Steel Co.	7	50–120	38,540
Taiyuan Flameproof Material Industry	1	60	2912
Xinan Chemical Material Plant	1	40	24

Results

Overview. The following 12 maps present the results of the calculations (all maps give isolines of SO_2 concentrations, average for a meteorological situation [hour-by-hour] as in November 2000):

Map 1 Scenario 1: Baseline 2005: Actual SO_2 concentrations.

Map 2 Scenario 2. Actual concentrations. Seller: Power Plant 1

Map 3 Scenario 3. Actual concentrations. Seller: Taiyuan Iron & Steel

Map 4 Scenario 4. Actual concentrations. Seller: Power Plant 1

Map 5 Scenario 5. Actual concentrations. Seller: Power Plant 2

Map 6 Scenario 6. Actual concentrations. Sellers: Power Plant 1 and Taiyuan Flameproof Material Industry

Map 7 Scenario 1. Difference in concentrations, relative to base case 2000.

Map 8 Scenario 2. Difference in concentrations, relative to baseline 2005 situation. Seller: Power Plant 1

Map 9 Scenario 3: As Scenario 2, but with Taiyuan Iron & Steel as seller.

Map 10 Scenario 4. Difference in concentrations, relative to baseline. Seller: Power Plant 1

Map 11 Scenario 5: As Scenario 4, but with Power Plant 2 as seller.

Map 12 Scenario 6. Difference in concentrations, relative to baseline.

Map elements included are water and road links. The position of road links has not yet been quality checked, and their positions may not be completely correct.

The maps show the locations of the stacks included in the database. They are in two separate areas, centrally located in the modeling area, to the west and to the east of Fenji River. The main wind directions in the area are from the SSE and NNW. The isolines of high SO_2 concentrations reflect the location of the stacks combined with the stack height effect and distribution effect of the main wind directions.

Maps for the trading scenarios also show the locations of the selling and buying companies.

Changes in the concentration distribution resulting from the scenarios

The main results can be summarized as follows:

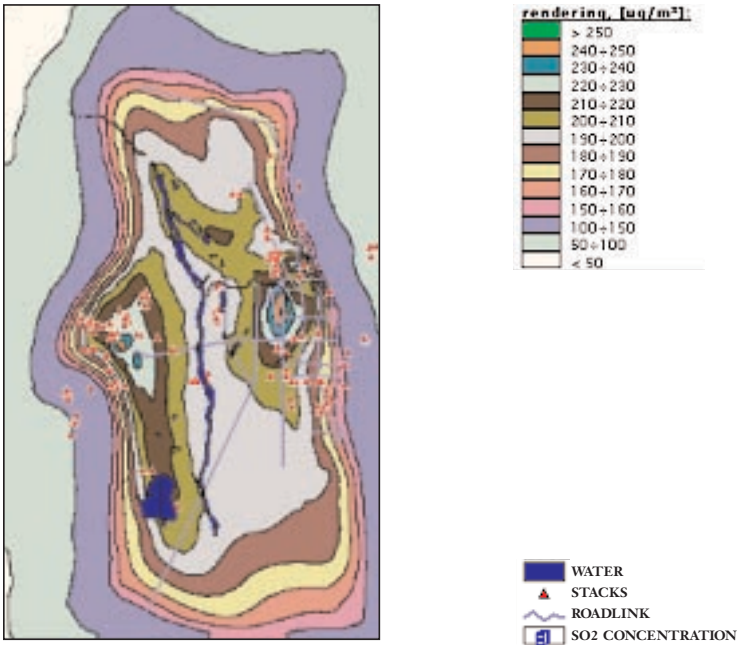
1. The calculated SO_2 concentrations for the base case situation, which give monthly average for November 2000, are fairly well in line with measured concentrations: the measured SO_2 concentration for Taiyuan for the heating season in 2000, averaged over all monitoring stations, was about 350 μ/m^3 (Inception Report, NORAD project). The calculations give concentrations for November 2000 ranging within 250–400 $\mu g/m^3$ in the part of the Taiyuan area where the monitoring stations are located. Note that for the calculations, emissions do not vary with time. With a proper time variation in the emissions, they would be higher in the heating season, resulting in higher calculated concentrations.

   This does not constitute a validation of the modeling results but shows that the model, based upon the emissions that are included in the emissions inventory, gives concentrations at approximately the same level as the measurements.

MAP 1

Scenario 1: SO_2 Baseline for year 2005 (Taiyuan)

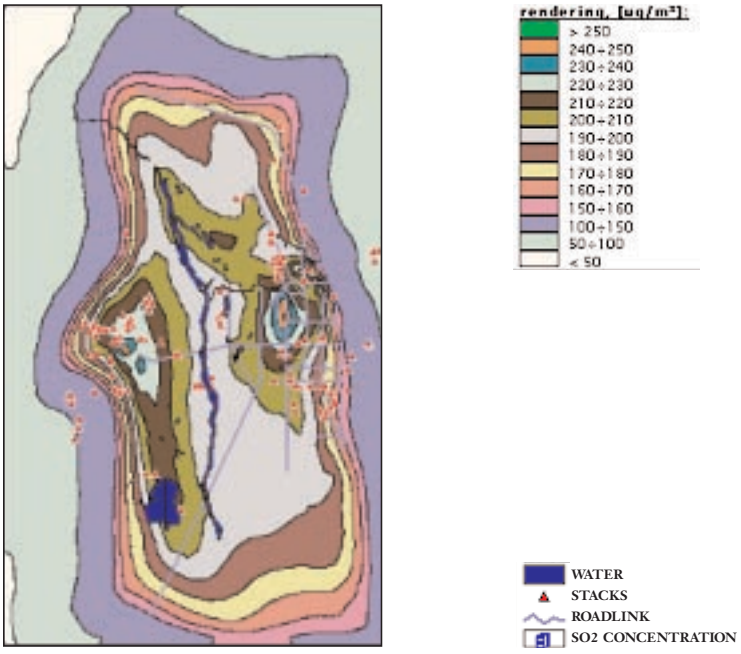
Average Concentration for November



MAP 2

Scenario 2: Trading between Power Plant 1 and Taiyuan Iron & Steel

Seller: Power Plant 1



2. Present (base case 2000) and baseline 2005 situation: The concentration distribution shows that there are large concentration gradients within the central city. Concentrations are highest in the east-central part of the city, in the area southeast of the Taiyuan Iron & Steel area, and are heavily influenced by those emissions.

3. Scenario 1, from 2000 to 2005: The point source emissions reduction of 50% resulted in a maximum reduction in SO_2 concentration of more than 0.120 mg/m^3, or about 30% of the 2000 concentration. The average concentration over the entire model area was reduced by about 0.045 mg/m^3, corresponding to about 25% of this concentration in 2000.

4. *Trades between Power Plant 1 and Taiyuan Iron & Steel (Scenarios 2 and 3)*
The trade results in the following changes:

   ■ The trade from Power Plant 1 to Taiyuan Iron & Steel (Maps 2 and 8) gives significantly *increased* concentrations in the already most-exposed area east of the city center, because of the increased emissions from Taiyuan Iron & Steel. The increase goes as high as about 0.035 mg/m^3 in the most exposed area. The corresponding decrease of SO2, in the area affected most directly by the Power Plant 1 emissions, is minimal.

   ■ The opposite trade (from Taiyuan Iron & Steel to Power Plant 1, Maps 3 and 9) naturally gives similarly *reduced* concentrations near Taiyuan Iron & Steel and very modestly increases levels in a sector south of Power Plant 1.

   Thus, what happens with emissions from Taiuyan Iron & Steel, with its relatively lower stacks (50–120 meters), determines the changes in the air quality.

5. *Trades between Power Plants 1 and 2 (Scenarios 4 and 5)*
The shift of emissions between Power Plant 1 and Power Plant 2 also results in changes in concentrations in the most exposed areas, this time limited to a maximum change of about 6 μg/m^3. The changes are much smaller than for Scenarios 1 and 2 because the power plant stacks are much higher than the Taiyuan Iron & Steel stacks.

6. Scenario 6: The additional modest trade between a plant just north of Taiyuan Iron & Steel as seller and a plant farther north as buyer (in addition to the Scenario 2 trade between Power Plant 1 and Taiyuan Iron & Steel) results in rather small additional concentration changes (Map 8). But the maximum difference did reduce concentrations from 0.038 mg/m^3 in Scenario 2 to 0.031 mg/m^3 in this scenario.

7. All the trade scenarios with shifting of emissions from Power Plant 1 to Taiyuan Iron & Steel or to Power Plant 2 resulted in increased SO_2 concentrations in areas of Taiyuan City fairly close to the central area. If the population density is large in this area, the trades result in increased population exposure in the high end of the population exposure distribution.

Changes in average and maximum concentrations in the modeling area

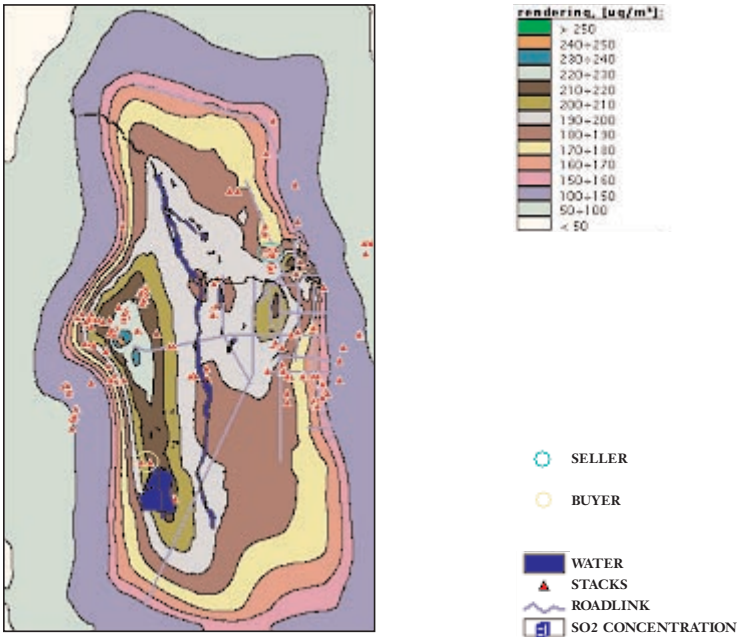
Table 3 gives changes in average and maximum SO_2 concentrations in the modeled area (1 × 1 km^2 grid) for the various scenarios.

The 50% reduction in point source emissions for Scenario 1 (from 2000 to 2005) results in a reduction in average SO_2 concentrations from about 0.188 mg/m^3 to about 0.143 mg/m^3 (about

MAP 3

Scenario 3: Trading between Power Plant 1 and Taiyuan Iron & Steel

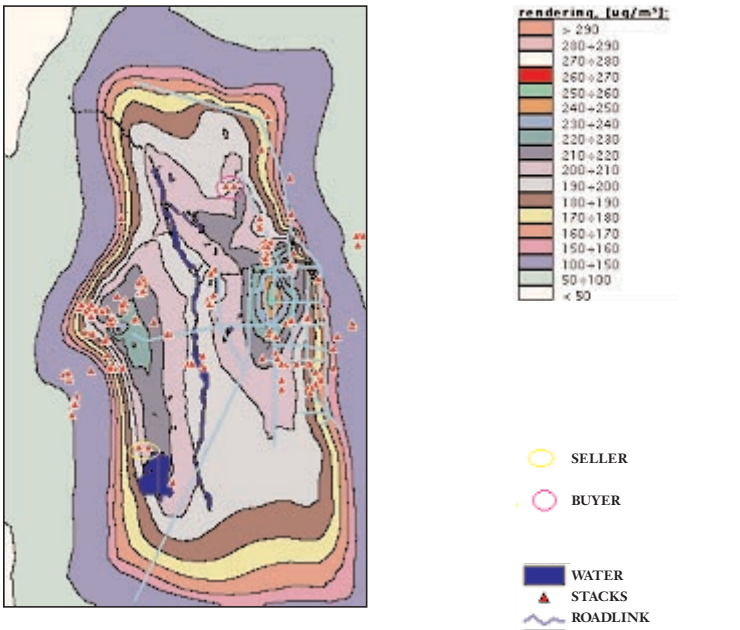
Seller: Taiyuan Iron & Steel



MAP 4

Scenario 4: Trading between Power Plant 1 and Power Plant 2

Seller: Power Plant 1



24%). The concentration contribution from the area source emissions (small-scale combustion of coal) as well as the influence from the regional SO_2 background (estimated to 0.02mg/m^3) results in reductions much less than 50%. The maximum concentration was reduced by about 33%.

The trading scenarios result naturally in considerably less changes in the concentration field on the average and maximum concentrations, since the trades involve much smaller emissions changes than the large 50% (expected) emissions decrease from 2000 to 2005.

Scenario 2 (10,000 tons/year traded from Power Plant 1 to Taiyuan Iron & Steel) results in a 0.0046 mg/m^3 average *increase* (3.2%), but the maximum concentration increased more (about 15%).

Scenario 3 (10,000 tons/year from Taiyuan Iron & Steel to Power Plant 1) resulted in similar *decreases*.

The additional modest trade between lower stack sources resulted in little additional change, although the maximum concentration was reduced from 0.038 to 0.031mg/m^3.

Scenarios 4 and 6 (10,000 tons/year between Power Plants 1 and 2) gave only small changes in the SO_2 concentration field.

Conclusions

1. The baseline Scenario 1 (50% flat reduction expected for all point source SO_2 emissions in the database) naturally resulted in a substantially reduced SO_2 concentration in the area. However, the relatively large influence on SO_2 of the small area-distributed sources in the area and the re-

TABLE 3

Changes in Average and Maximum Concentrations by Scenario

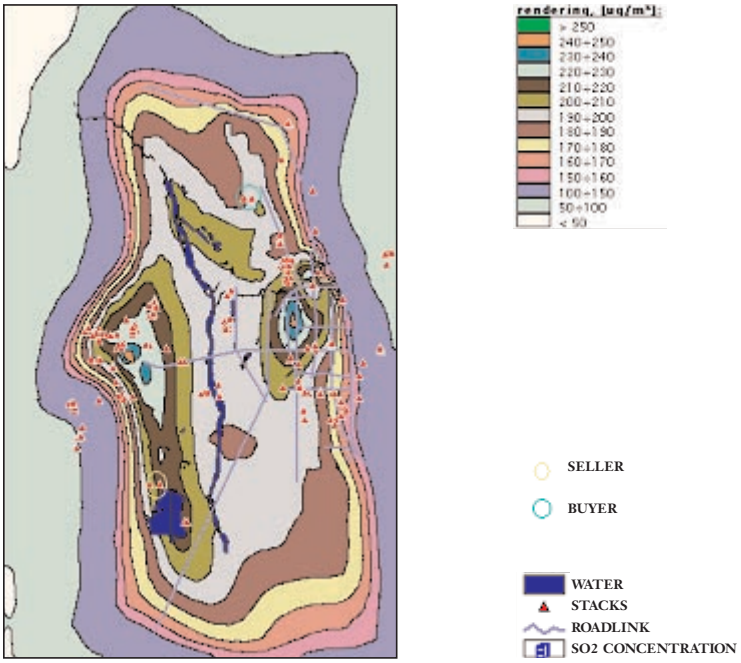
Scenario	Description	Average concentration (μ/m^3)	Average concentration difference (relative to baseline 2005)	Maximum concentration (μ/m^3)	Maximum concentration difference (relative to baseline 2005)
Base case	2000	187.6		374	
1	Baseline 2005	143.4	- 44.2*	252	- 122*
2, 3	Trades PP1 — TI&S		+ 4.6		+ 38
	- seller: PP1		- 5.2		- 38
	- seller: TI&S				
4, 5	Trades PP1 — PP2		+ 0.7		+ 7
	- seller: PP1		- 1.2		+ 4
	- seller: PP2				
6	Scenario 2 + modest trade		+ 4.3		+ 31

* Relative to base case 2000

MAP 5

Scenario 5: Trading between Power Plant 1 and Power Plant 2

Seller: Power Plant 2



MAP 6

Scenario 6: Scenario 2 + Trading Between Modest Enterprises

gion diluted the effects and resulted in only a 33% reduction in average SO_2 concentrations in the model area.

2. The trade scenarios represented much smaller changes in SO_2 emissions than the baseline, and thus produced less change in SO_2 concentrations.

3. All trades from Power Plant 1 to Taiyuan Iron & Steel or Power Plant 2 resulted in increased SO_2 concentrations in the area. The amount of increase was determined by the positions of the buying and selling sources as well as by the height of their stacks.

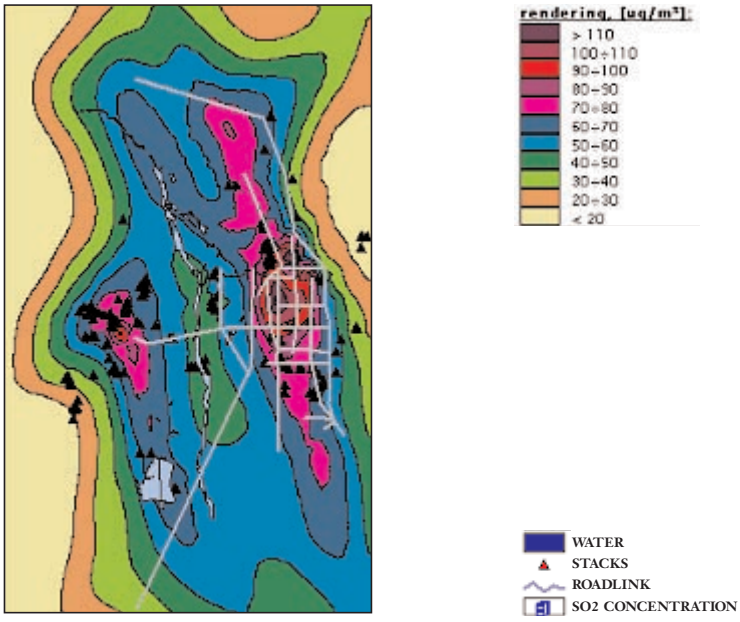
4. A trade from the high stacks of Power Plant 1 to the lower stacks of Taiyuan Iron & Steel, located close to the city center, resulted in a substantial increase in the SO_2 concentration in a densely populated area.

5. Similarly, trading from Taiyuan Iron & Steel to Power Plant 1 resulted in substantial decreases.

6. Emission trades within an urban airshed, with locally high concentration areas due to influence from local sources, should be carried out with a view to the local changes in concentration levels. Some of the important parameters to consider are stack heights and source location relative to population centers.

MAP 7

Difference Between Base Case 2001 and Baseline 2005



MAP 8

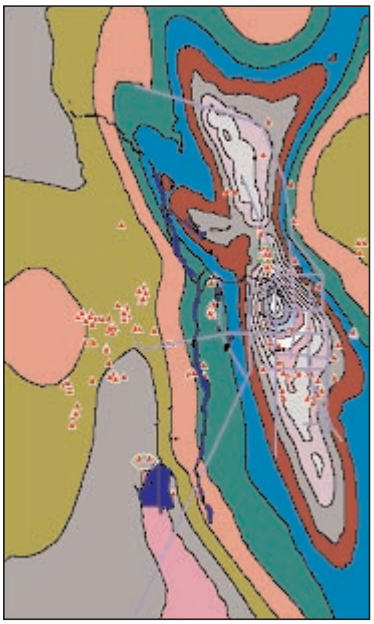
Difference Between Scenario 2 and Baseline

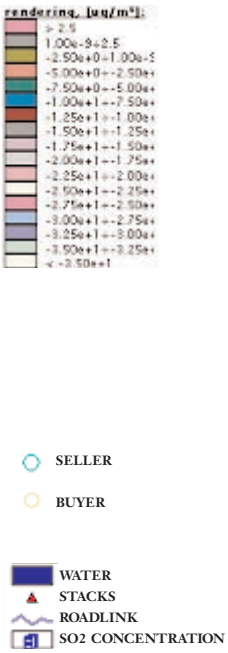
Seller: Power Plant 1

MAP 9

Difference Between Scenario 3 and Baseline

Seller: Taiyuan Iron & Steel

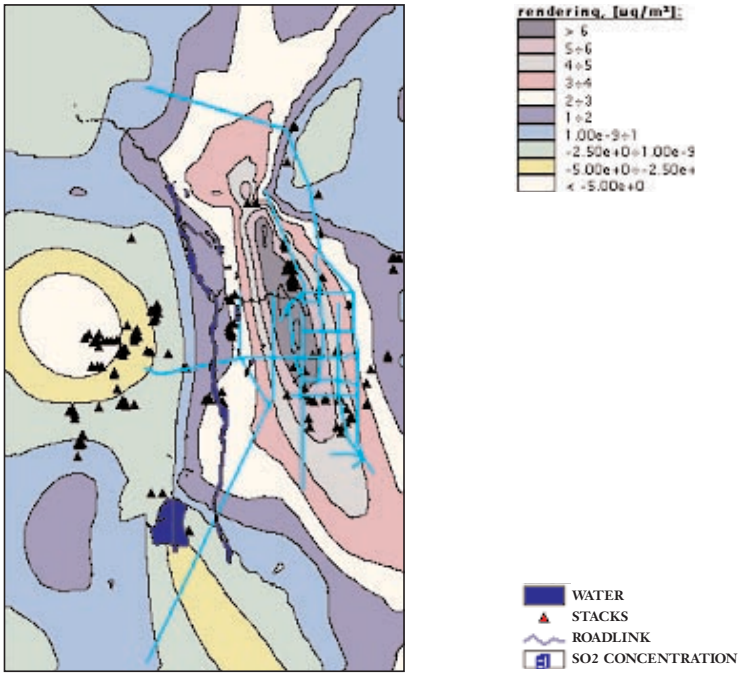




MAP 10

Difference Between Scenario 4 and Baseline

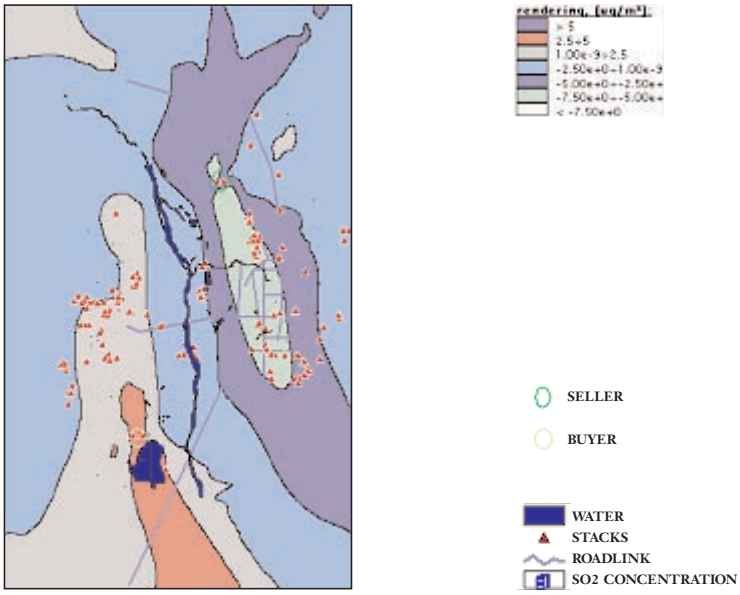
Seller: Power Plant 1



MAP 11

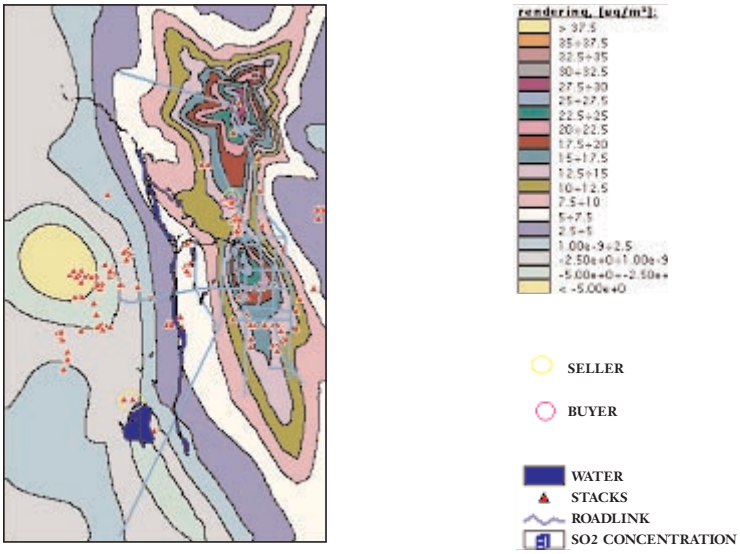
Difference Between Scenario 5 and Baseline

Seller: Power Plant 2



MAP 12

Difference Between Scenario 6 and Baseline



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Annex 1

TY Trading Scenarios for Year 2005

SCENARIO 1

Baseline for Year 2005

50% reduction for all the SO_2 point sources in database as the baseline from 2000 to 2005.

SCENARIO 2

Trading from Power Plant 1 to Taiyuan Iron & Steel

Power Plant 1 sells 10,000 tons/year SO_2 to Taiyuan Iron & Steel; these emissions are distributed in Iron & Steel according to the emissions fraction of each stack.

	Before trading	After trading
Power Plant 1	28,160	18,160
Iron & Steel	19,269	29,269

Unit: tons/year

SCENARIO 3

Trading from Taiyuan Iron & Steel to Power Plant 1

Iron & Steel sells 10,000 tons/year SO_2 to Power Plant 1.

	Before trading	After trading
Power Plant 1	28,160	38,160
Iron&Steel	19,269	9,269

Unit: tons/year

SCENARIO 4

Trading from Power Plant 1 to Power Plant 2

Power Plant 1 sells 10,000 tons/year SO_2 to Power Plant 2, as follows.

	Before trading	After trading
Power Plant 1	28,160	18,160
Power Plant 2	20,400	30,400

Unit: tons/year

SCENARIO 5

Trading from Power Plant 2 to Power Plant 1

Power Plant 2 sells 10,000 tons/year SO_2 to Power Plant 1.

	Before trading	After trading
Power Plant 1	28,160	38,160
Power Plant 2	20,400	10,400

Unit: tons/year

SCENARIO 6

Scenario 2 + Trading for Modest Enterprise

One modest enterprise (Taiyuan Flameproof Material Industry), with SO_2 emissions of 2912 tons/year, trades with Xinan Chemical Material Plant.

	Before trading	After trading
Taiyuan Flameproof Material Industry	2,912	0
Xinan Chemical Material Plant	24	2,936

Unit: tons/year

Annex 2

Point Sources of SO_2 Emissions in Taiyuan, Shanxi Province, 2000

Name of the industries	Component	year 2000	year 2005	Unit
A_STRTEXT	B_STRTEXT	emission	emission	D_STRTEXT
太钢一钢厂TG YGC	SO2	56520.00	28100.00	ton/year
太钢二钢厂TG EGC	SO2	40800.00	20400.00	ton/year
太钢炼材公司TG NC	SO2	17672.82	8836.41	ton/year
太钢炼化厂TG JHC	SO2	13000.00	6500.00	ton/year
太钢炼铁厂TG liantie chang	SO2	7554.00	3777.00	ton/year
山西半光玻璃有限公司SX Huaguangboli	SO2	2805.04	1402.52	ton/year
太铁车轮厂Tai tie Clun	SO2	1723.90	861.95	ton/year
太原钢铁水球股份有限公司Shitou SNC	SO2	1281.78	640.89	ton/year
山西神州煤电焦化股份有限公司焦化厂SX SZMD JH	SO2	1267.06	633.53	ton/year
太原重型机械集团有限公司TY ZJ	SO2	961.08	480.54	ton/year
山西焦煤集团公司西铭矿XiShan XMK	SO2	909.00	454.50	ton/year
太原化学工业集团有限公司焦化厂TY HG Jiaohua	SO2	907.00	453.50	ton/year
太原市长城光电子工业公司TY GCZGYGS	SO2	706.20	353.10	ton/year
山西焦煤集团公司事业公司XiShan SYGS	SO2	604.30	302.15	ton/year
山西焦煤集团公司机电总厂XiShan JDZC	SO2	564.74	282.37	ton/year
太钢发电厂TG FDC	SO2	513.46	256.73	ton/year
太原煤炭气化（集团）有限责任公司煤研石热电厂TY MQH MGSDC	SO2	485.72	242.85	ton/year
山西焦煤集团公司官地矿XiShan GDK	SO2	335.58	167.79	ton/year
山西焦煤集团公司杜儿坪矿XiShan duping K	SO2	308.48	154.24	ton/year
太原轧车 车钢厂TY JCCL	SO2	307.00	153.50	ton/year
山西焦煤集团公司水球厂XiShan SNC	SO2	107.96	53.98	ton/year
山西兴安化学工业（集团）有限责任公司SX XA	SO2	96.72	48.36	ton/year
山西焦煤集团公司职工总医院XiShan hospital	SO2	93.78	46.89	ton/year
太铁机务段Tai tie JWJ	SO2	86.16	43.08	ton/year
国腾实业股分有限公司Hongteng SY	SO2	74.62	37.31	ton/year
山西焦煤集团公司化工厂XiShan fachang	SO2	70.58	35.29	ton/year
山西焦煤集团公司万峰公司XiShan WLGS	SO2	70.44	35.22	ton/year
Name of the industries	Component	year 2000	year 2005	Unit
A_STRTEXT	B_STRTEXT	emission	emission	D_STRTEXT
茂盛炭素材料批发市场Maosheng ds	SO2	62.48	31.24	ton/year
二十一中 21zhong	SO2	50.24	25.12	ton/year
铁七院Heqiyuan	SO2	49.86	24.93	ton/year
成成中学Chengcheng zhongxue	SO2	45.92	22.96	ton/year
双喜轮胎工业股份有限公司Shuang xi LT	SO2	40.52	20.26	ton/year
山西省工业企业管理学校SX GYQYGLschool	SO2	39.60	19.80	ton/year
山西焦煤集团公司矸石电厂XiShan GSDC	SO2	38.84	19.42	ton/year
山西省太原市高速客运有限公司SX TYGS	SO2	37.34	18.67	ton/year
太原车钢段Tai tie CL	SO2	33.02	16.51	ton/year
老军营供中供热站Laojunying GRZ	SO2	31.38	15.69	ton/year
广播电视厅房管科SX GBDST	SO2	30.06	15.03	ton/year
旭兴花园Xuxing huayuan	SO2	29.60	14.80	ton/year
佳地苑 Jiadi huayuan	SO2	28.80	14.40	ton/year
山西省话剧院SX huajuyuan	SO2	28.66	14.33	ton/year
山西省高级人民法院 SX faiyuan	SO2	26.70	13.35	ton/year
山西省科委SX Kewei	SO2	26.22	13.18	ton/year
太原市合作大楼TY HZDL	SO2	26.28	13.14	ton/year
中铁高机械配件总公TSJ	SO2	26.26	13.13	ton/year
山西焦煤集团公司金城公司XiShan JCGS	SO2	23.18	11.59	ton/year
山西省司法厅SX CFT	SO2	21.56	10.78	ton/year
山西省二轻总合SX EQZH	SO2	20.40	10.20	ton/year
山西焦煤集团公司新技术产业区XiShan new JS	SO2	17.20	8.60	ton/year
山大附院 Shanda SY	SO2	16.70	8.35	ton/year
太原图书馆TY tushuguan	SO2	15.94	7.97	ton/year
山西省水利大厦Shuili Dasha	SO2	15.36	7.68	ton/year
山西焦煤集团公司供应公司XiShan GYGS	SO2	14.86	7.43	ton/year
山西省四建集团SX sj(4th)	SO2	14.74	7.37	ton/year
山西省太原市建筑工程公司SX TYJZGCGS	SO2	13.54	6.77	ton/year
山西饭店 SX fandian	SO2	13.30	6.65	ton/year
Name of the industries	Component	year 2000	year 2005	Unit
A_STRTEXT	B_STRTEXT	emission	emission	D_STRTEXT
侯候制农有限公司YYfzy	SO2	12.10	6.05	ton/year
山西省城乡规划设计院 Guihua shejiyuan	SO2	11.42	5.71	ton/year
狄村村委会Dicun cunweihui	SO2	11.42	5.71	ton/year
山西省高速公路管理局SX GSGLGLJ	SO2	10.86	5.43	ton/year
煤化所Meihuasuo	SO2	9.78	4.89	ton/year
山西省太原市高速客运有限公司SX TYGS	SO2	9.68	4.84	ton/year
山西省长途电信综务局SX dianxing	SO2	9.48	4.74	ton/year
太化集团分厂Taihua FC	SO2	8.16	4.08	ton/year
大地钢铁厂Da di GSC	SO2	7.86	3.93	ton/year
山西省林业大厦Linye Dasha	SO2	4.52	2.26	ton/year
太原图书馆TY tushuguan	SO2	3.84	1.92	ton/year
Total	SO2	150565.20	75028.31	ton/year

APPENDIX 8

SO_2 Allocation Scheme for Enterprises Participating in Emissions Trading in Taiyuan City in 2002–05

Issued by Taiyun City Government on December 6, 2002

No.	Enterprise	2000 Actual emission (T)	2001 Actual emission (T)	2002 Emissions January to June (T)	2002 Allowance (T)	2003 Allowance (T)	2004 Allowance (T)	2005 Allowance (T)	Reduction rate for 2001–05
1	Taiyuan Power Plant 1	60624	56321	23792	51117	39411	27706	16000	72%
2	Taiyuan Power Plant 2	35669	40800	24584	35870	29580	23290	17000	58%
3	Taiyuan Iron & Steel Group Company	21033	22006	11358	19000	15667	12333	9000	59%
4	Shanxi Coal and Power Group Company LTD.	3479	4529	1508	2761	2420	2080	1739	62%
5	Taiyuan Heavy Machinery Making Group Company LTD.	2194	1798	499	1405	1263	1122	980	45%
6	Dongshan Thermal and Power Company LTD of Taiyuan Gangyu Group	1472	1672	861	1501	1274	1047	820	51%
7	Shanxi Shenzhou Coal-Power-Coke Stock Company		4468		3351	39411	27706	2880	36%
8	Taiyuan Railway Bureau	1190	360		600	496	392	288	20%
9	Taiyuan Chemical Industry Group Company LTD.	1312			262	525	787	40%	
	Fertilizer Plant of Taiyuan Chemical Industry Group	699	419	60	547	448	350	251	40%
	Chemical Plant of Taiyuan Chemical Industry Group		187			38	75	113	40%

No.	Enterprise	2000 Actual emission (T)	2001 Actual emission (T)	2002 Emissions January to June (T)	2002 Allowance (T)	2003 Allowance (T)	2004 Allowance (T)	2005 Allowance (T)	Reduction rate for 2001–05
9	Coking Plant of Taiyuan Chemical Industry Group	903	706	252	697	606	514	423	40%
10	Taiyuan Shitou Cement Stock Company LTD.	648	537	255	486	432	378	324	40%
11	Xinkai Textile and Dyeing company LTD. of Taiyuan	417	340	142	309	276	243	210	38%
12	Taiyuan Locomotive and Vehicle Plant	369	307	125	280	248	217	185	40%
13	Taiyuan Heating Supply Company	542	350		340	293	247	200	43%
14	Taiyuan Aluminum Plant	143	102	64	103	89	74	60	41%
15	State-owned Dazong Machinery Plant	281	245		184	39411	27706	147	40%
16	Taiyuan Aviation Instrument Company LTD	389	351		263	39411	27706	210	40%
17	Fenxi Machinery Plant	120	132		99	39411	27706	79	40%
18	Shuangxi Tire Industry LTD	428	365		274	39411	27706	230	37%
19	Taiyuan Cigarette Plant	316	372		279	39411	27706	223	40%
20	Xin'An Chemical Material Plant		66		50	39411	27706	40	39%
21	Shanxi Machinery Bed Plant		260		195	39411	27706	100	62%
22	Jinxi Machinery Company		462		346.5	39411	27706	180	61%
23	Huayuan Electric Chemical Limited Company	449	704	230	292	311	331	350	50%

APPENDIX 9

Implementation of SO_2 Emissions Trading in Taiyuan City in 2001–05: Procedural Guide for Enterprises

1. The Taiyuan City SO_2 Emissions Trading Program

Background

The Taiyuan City government recently issued a regulation, Administrative Regulation for SO_2 Emissions Trading in Taiyuan City (see Annex 1), to create an emissions trading program to reduce emissions of sulfur dioxide (SO_2) from the largest emitting enterprises in the city. The goal of the emissions trading program is to reduce SO_2 emissions by approximately 50% below 2000 emission levels. The program provides enterprises with flexibility to meet their emissions reduction obligations using a strategy appropriate for their circumstances.

The Taiyuan City SO_2 trading program is a form of emissions trading called "cap-and-trade." Cap-and-trade is an environmental policy tool that uses economic forces to reduce pollution at a lower cost than traditional command-and-control regulations. The Taiyuan City SO_2 trading program establishes an overall cap, or limit, on the total emissions from all enterprises included in the program (see Annex 2 for a list of enterprises). The Taiyuan Environmental Protection Bureau (TEPB) will enforce the cap on total emissions. This will ensure that the emissions from all sources included in the program will not exceed the allowable level.

The cap is divided into allowances, or authorizations, to emit 1 ton of SO_2 during a calendar year. For each ton of SO_2 it releases, each participating enterprise must submit one allowance to TEPB during the reconciliation period (for information about schedules, see Trading Program Timeline section). If an enterprise has surplus allowances at the end of the year, it can bank them for use in future years. If an enterprise does not hold sufficient allowances to cover its emissions, TEPB will assess penalties for each excess ton emitted.

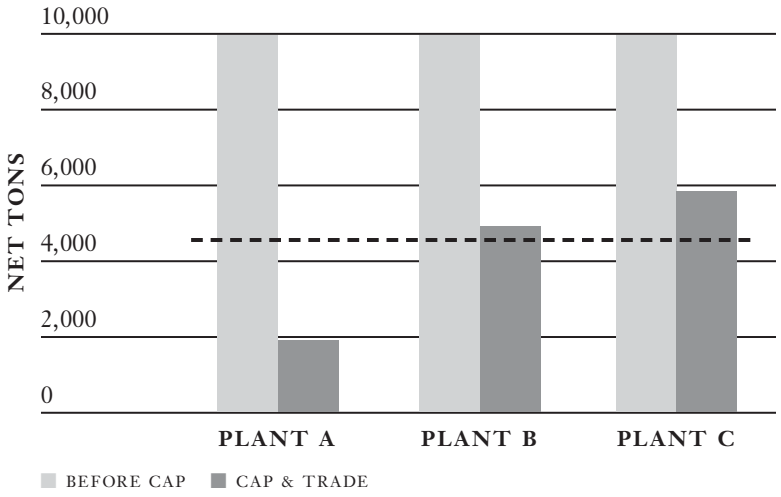
A feature of the Taiyuan City SO_2 trading program is the ability to trade allowances between enterprises. The program gives enterprises an incentive to cut pollution more than required because any surplus allowances can be sold, subject to TEPB approval, to other enterprises that need additional allowances for compliance. The program also provides flexibility to enterprise managers to choose the emissions reduction strategy that works best at the least cost for their facility.

The trading program's flexibility derives from the freedom of each enterprise to choose its own compliance strategy (e.g., install control technology, improve efficiency, switch to cleaner fuel) and trade allowances to achieve that strategy at the lowest cost. The benefits of emissions trading come from the different costs of emissions reductions across the enterprises included in the program. Enterprises that can reduce emissions at a lower cost have an incentive to reduce

CAP & TRADE EXAMPLE

Enterprises A, B, and C emit 30,000 tons of SO_2. Under the cap, total emissions must drop by 50% to 15,000 tons, which is distributed as 5,000 allowances per plant.

- *Enterprise A installs controls on its smokestacks, cutting emissions to 2,000 tons. Plant A has 3,000 surplus allowances.*
- *Plant B shifts to cleaner burning coal. Emissions are cut to 5,000 tons—meeting its target.*
- *Plant C expanded operations and was only able to cut emissions to 6,000 tons. Plant C is 1,000 tons over their target.*



Using cap and trade, Plant C can purchase 1,000 allowances from Plant A, giving Plant A extra revenue (a reward for better performance) and allowing Plant C to meet the requirement to submit one allowance for each ton of emissions (5,000 assigned allowances plus 1,000 purchased allowances). With flexibility to choose their own solutions, all three plants have met the new limit.

emissions more than required and sell their extra allowances or save them for use in the future. Enterprises that have higher costs for reducing emissions can purchase allowances to defer or avoid implementation of some costly control measures. For a given cap on emissions, a cap-and-trade program achieves the emissions reduction objective at lowest economic cost.

Enabling Legislation

The rules for SO_2 emissions trading in Taiyuan City in 2001–05 are formulated in accordance with the Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City and the Administrative Regulation for SO_2 Emissions Trading in Taiyuan City. The regulations were established to carry out the city's SO_2 Total Emissions Control (TEC) requirements in 2001–05 at lower cost, to reduce human health effects on the citizens, and to coordinate economic and environmental goals.

Emissions Target

The city's goals are set out in Taiyuan National Economic and Social Plan Outline in 2001–05. By 2005, the total low-sulfur coal usage should reach 9 million tons and SO_2 emissions should be reduced by 125,000 tons below 2000 levels. By the end of the Five-Year Plan period, if the goal is achieved, total suspended particles, SO_2, and NO_2 daily average concentrations should meet the Class II national air quality standard so that at least 70.9% of the days in each year should have air quality at or better than the Class II standard.

In 2000, SO_2 emissions in Taiyuan were 250,000 tons, and from 2001 to 2005, SO_2 emissions in the city are supposed to be reduced by at least 60%. Therefore, to meet SO_2 control requirements in 2001–05, TEPB has required major polluting sources to cut emissions by at least 60% from 2001 levels.

2. Enterprises Required to Participate in the Program

The Taiyuan City government has identified the enterprises that are the largest SO_2 emitters. These enterprises are the first participants in the emissions trading program. Other sources will not participate in the trading plan during 2002–05 but may be added in the future. The participating enterprises are listed in Annex 2.

TEPB considered two main factors when selecting these enterprises:

- *Size*. All the enterprises are large SO_2 sources in the city;
- *Contribution*. SO_2 emissions from the enterprises currently account for approximately 60% of the total emissions in the city, and their emissions must be reduced if the city is to achieve its TEC targets by 2005.

3. Requirements for Participating Enterprises

All enterprises participating in the Taiyuan City SO_2 emissions trading program have certain obligations. Their primary responsibilities include measuring and reporting total emissions to TEPB and holding at least one allowance for each ton of SO_2 emitted during the calendar year. Enterprises must also comply with requirements of other applicable environmental regulations (e.g., the pollution levy).

Select an authorized account representative (AAR) and alternate AAR

Each enterprise must designate one primary authorized account representative (AAR). The AAR is the person responsible for transferring allowances, managing the enterprise's allowance account, and certifying all reports for the emissions trading program, including all reports to the SO_2 allowance tracking system (ATS) and the emissions tracking system (ETS). The AAR is also the person that TEPB will contact with questions about documentation or information about allowance auctions and possible trading partners.

Each enterprise must submit a certificate that identifies a primary AAR and alternate AARs in case the primary AAR is not available (see Annex 3 for the Account Certificate of Representation form). The certificate should include the following information:

- Complete enterprise name
- Address and area where enterprise is located
- Enterprise and industry code
- The name and contact information for the AAR and alternate AARs, including
  - The level of authority for each designated official, and, if more than one is listed, the order of authority
  - Address
  - Phone and fax numbers
  - E-mail address
- Stamps for each AAR and alternate AAR along with the following certification language:

"I am authorized to make this submission on behalf of the owners and operators of [insert name of enterprise]. I certify under penalty of law that I have personally examined, and am familiar with, the statements and information submitted in this document and all its attachments. Based on my inquiry of those individuals with

primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete. I am aware that there are penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine."

Update the AAR or alternate AAR

If an enterprise wishes to change or add an AAR, it should submit a new certificate with the above information. To delete an AAR, the enterprise should submit a new certificate with the above information for the inactive AAR and instructions to TEPB to delete the AAR.

Establish an account

Each enterprise must have an allowance account in TEPB's allowance tracking system. The purpose of the account is to keep track of SO_2 allowances, including the allowances allocated by TEPB, purchased or sold by each enterprise, and banked for future use. After TEPB receives an enterprise's Account Certificate of Representation form, staff will establish an allowance account for the enterprise and assign an account number that the enterprise and AAR must use in all TEPB correspondence and forms.

Hold sufficient allowances to comply with requirements

Each enterprise must hold allowances equal to or greater than its annual SO_2 emissions. As a starting point, an enterprise's "assumed" reduction obligation is equal to the enterprise's predicted emissions minus its initial allowance allocation. Each enterprise can meet its emissions requirements by using a combination of the allocated allowances, additional allowances obtained from other market participants, and auctioned allowances together with any emissions control strategies.

No specific mass emissions limit applies — enterprises demonstrate compliance by holding enough allowances to cover SO_2 emissions during the year.

Establish an emissions monitoring and data collection system

The Administrative Regulation of SO_2 Trading in Taiyuan sets a goal for each enterprise in the program to install continuous emissions monitors (CEMs) to monitor their mass SO_2 emissions. Until such monitors are installed and certified, fuel use and other data submitted using the emissions tracking system as well as TEPB- and self-monitored data will be used to estimate SO_2 emissions. See details about ongoing monitoring and reporting below.

4. Details of Trading Program

Allocating Emissions Allowances

TEPB has already established each enterprise's emissions targets through 2005. These emissions targets can be found in Annex 2.

At the beginning of the program, emissions allowances will be issued for each year of the period 2002–05. At the end of each compliance period (calendar year), each enterprise is responsible for having at least one allowance in its ATS account for each ton of SO_2 it emitted during the compliance period. If production at one of the enterprises has shifted to a facility not participating in the emissions trading program, or if the enterprise has shut down because of central

heating or another reason, TEPB will reassess the emissions and alter the allowance allocation for the current and subsequent years.

The procedures determining allocations after 2005 will be established by TEPB and provided prior to January 1, 2004, to all enterprises participating in the emissions trading program.

Trading Emissions Allowances

The Administrative Regulation for SO_2 Emissions Trading in Taiyuan City establishes that trading is voluntary. If two sides agree, they should sign the Taiyuan City Trading Contract for SO_2 Allowance (see Annex 4). The trade will be valid after it has been approved and filed by TEPB.

TEPB issues allowances for each compliance year. Such allowances can be traded ahead of the vintage year but cannot be used for compliance prior to this date. If in 2002, for instance, Source A purchases 100 allowances with a vintage year of 2004 (i.e., the allowances are for the 2004 compliance year) from Source B, these 100 allowances can be used only in 2004 or later, not in 2002 or 2003.

If an enterprise desires to trade emissions allowances but does not have a specified counter party, the enterprise can submit a message of intent to trade allowances (whether to buy or sell) to TEPB. If another enterprise has also expressed interest, TEPB may facilitate initial communication between the enterprises.

Auctioning Emissions Allowances

In December of each year, TEPB will auction surplus allowances to participating enterprises. The number of allowances available will be based on TEC limits and expected emissions from sources that are not participating in the emissions trading program.

The purpose of the auction is to make allowances available to new sources and to provide opportunities to avoid punishment for those that have not met their emissions requirements during the compliance period. In the period 2002 to 2005, only the enterprises listed in Annex 2 and newly built emissions sources can participate in the auction.

The allowances for auction come from emissions reductions resulting from measures taken by TEPB. Another source of allowances may be enterprises that have been shut down or that have shifted production (see Article 10 of the regulation). The auctioned allowances will not affect the allocation of the allowances for the enterprises participating in the program.

The auction should be carried out under the following terms:

- On the first workday of December each year, TEPB will initiate the auction by circulating information concerning the number of SO_2 allowances available for auction to participating enterprises.

- Enterprises that wish to purchase allowances at auction must complete the Bidding Form for SO_2 Emissions Allowance Auction in Taiyuan City (see Annex 5), and report to TEPB the number of allowances they would like to buy and the proposed unit price.

- Seven, 14, and 21 days after initiating the auction, TEPB will publish the leading bids for all allowances at the auction. If an enterprise would like to increase its bid, it must complete a new Bidding Form for SO_2 Emissions Allowance Auction in Taiyuan City (see Annex 5) and report to TEPB. The final publication 21 days after TEPB initiated the auction will list the final results and will be the only report to include the name of the winning bidders.

■ The allowances sold at the auction may be used for compliance in the current compliance period or banked for future use.

■ Auction proceeds will be used by the local government to improve air quality.

Banking Emissions Allowances

At the end of each year, if an enterprise holds more allowances than its actual SO_2 emissions, it can bank the remaining allowances for future use or sale. To prevent excess use of banked allowances in any single year, banked allowances can be used only with the approval of TEPB. To apply, the enterprise must fill out Application Form for Use of SO_2 Emissions Deposit in Taiyuan City (see Annex *6.*)

Managing Emissions Trading

TEPB is responsible for managing the SO_2 emissions trading program. The bureau will use the allowance tracking system, the accounting system for the trading program, to track account information, authorized account representative details, allowance holdings, and allowance transactions.

Reporting Monitored Emissions and Other Data

A. SUPERVISION AND VERIFICATION OF EMISSIONS

Enterprises are responsible for the supervision, verification, and reporting of their emissions data, subject to examination and verification by TEPB. In its verification role, TEPB inspectors may make unannounced visits at facilities of participating enterprises, subject their stacks to testing with mobile CEM units or other equipment, and make other inquiries as necessary to meet its enforcement responsibilities.

The Taiyuan emissions tracking system is used to collect, verify, and maintain data about mass emissions, fuel purchases, and production at the enterprises participating in the emissions trading program. Throughout each month, enterprises must use the ETS to enter information, including the following:

■ changes in fuel inventories (e.g., beginning fuel inventory, fuel sales, fuel purchases, and fuel consumption);

■ characteristics of fuel (e.g., sulfur content);

■ production levels (e.g., quantity of electricity produced); and

■ measured emissions at each boiler.

At the end of each quarter, the enterprises must export all the data to a file and submit it to TEPB using appropriate methods (e.g., floppy disk or e-mail).

In addition to collecting the ETS data, TEPB will periodically monitor emissions at each facility and compare the emissions estimates to better reflect actual emissions at the enterprise.

B. QUARTERLY EMISSIONS REPORTING

For those enterprises that do not have access to computers, the AAR or alternate AAR must fill out and send to TEPB the self-reported SO_2 emissions, using the Quarterly Report Form of

SO_2 Emissions (see Annex 8). Forms should be sent to TEPB. TEPB will verify that the reports have been received.

5. Compliance Planning

Assessing Controls and Other Compliance Options

Many enterprises will have several SO_2 control options available. Choosing the mix of options that best fits from both an economic and an environmental perspective can be a difficult task. An enterprise's planning process can be complex and must factor in demand for products and the emissions associated with producing them. The enterprise also needs to assess its SO_2 control options, including allowance trades.

Long-Term Strategy

It is important to create a comprehensive long-term strategy that spans several years yet is flexible enough to be fine-tuned on a weekly or even daily basis. Aside from making fundamental infrastructure decisions, emissions control is essentially a function of making changes to the way an enterprise produces an output. Because facilities represent massive capital expenditures that can take many years to design and construct, a compliance plan needs to take a long view on how these resources will be used.

When developing a compliance strategy, an enterprise should develop emissions projections based on an analysis of a number of factors that can affect demand for its products. Consideration should also be given to how the enterprise will produce the products (e.g., which facilities and boilers will be used) and how it will provide ancillary services (e.g., heating for employees and buildings).

Quantitative Analysis

After the enterprise has developed estimates for demand and production, it can create base case scenarios (usually high, middle, and low cases) that, in turn, can be used to develop emissions forecasts. These scenarios provide the enterprise with a basis against which to compare its actual emissions performance throughout the compliance period.

In comparing expected emissions with the allowances it holds, an enterprise may find that it faces one of two situations: it may hold fewer allowances than its expected emissions, making it short allowances; or it may hold more allowances than its expected emissions, providing surplus allowances. Whether an enterprise is short or has excess allowances will determine its actions in the allowance market as it develops future strategies to address the situation.

If the enterprise has excess allowances, it may "bank" the surplus allowances or sell them to other enterprises. If the enterprise is short allowances, it has to decide whether to cut emissions before the end of the compliance period to bring emissions in line with allowance holdings or to purchase allowances from TEPB or from other enterprises.

Several emissions reduction strategies are available:

■ *Fuel choice*. Enterprises can switch from relatively high-sulfur fuels to low-sulfur fuels (e.g., low-sulfur coal, washed coal, natural gas) and sometimes achieve dramatic reductions in SO_2 emissions.

■ *Purchase steam.* Some enterprises can purchase steam from central heating plants or other enterprises to heat buildings. The source of the steam heat will, however, have to hold allowances to cover any emissions that would result from this generation, to preserve the integrity of the cap. An enterprise should note, however, that TEPB may reduce an allocation if an enterprise shifts production to another source.

■ *Production dispatch.* An enterprise with multiple boilers or turbines may run the lower-emitting units first, all other things being equal.

■ *Pollution control technology.* Certain technologies can be applied to a unit to control SO_2 emissions. Most pollution control technology decisions are long-term and capital intensive.

The ultimate long-term strategy is to achieve the necessary emissions reductions as cost-effectively as possible, implementing first those options that are operationally feasible and least costly. The final plan could include a combination of the above reduction measures and will take into account other business factors affecting the enterprise.

Short-Term Refinements

With the long-range plan as an operating template, enterprises can turn their attention to short-term factors that change constantly and, ultimately, can affect the level of SO_2 emissions. Enterprises should review their plans on a regular basis to revise assumptions and monitor progress.

6. Complying with the SO_2 Emissions Trading Program

Demonstrating Compliance

By the first business day of March, the AAR or an alternate AAR must certify that the enterprise is in compliance with the emissions limitation and the requirements of the trading program. To do this, the AAR must account for all of the enterprise's SO_2 emissions and compare these emissions with the number of allowances in the enterprise's allowance account. The total number of valid allowances must be equal to or greater than the total emissions for the year. If an enterprise does not have sufficient allowances, it is out of compliance. See the Enforcement section for a discussion of the penalties and other potential consequences for failing to meet the requirement to hold sufficient allowances to cover emissions.

You demonstrate compliance by holding enough allowances to cover your SO_2 emissions during the year.

Further, it is important that enterprises report to TEPB whether the facts underlying the basis for certification for any monitor or accepted methodology have changed since the previous submission. If a change has occurred, the enterprise must submit a technical description of the change plus information describing how emissions were determined when a change created the need to recertify a monitor.

Tracking and Deducting Allowances

Once TEPB receives and records your AAR Certificate of Representation, it will establish an allowance account in the ATS for your enterprise. All allowance transactions, including allocations and trades, will be registered in the enterprise's allowance account. The allowance accounts will have current information about the allowance holdings for the enterprises, including the quantity of allowances for each compliance year.

Note! You should submit your AAR account certificate of representation as soon as possible-you will not receive an allowance account until EPB receives that form.

After the compliance period is complete, TEPB will deduct allowances from each enterprise's allowance account equal to the enterprise's SO_2 emissions during the calendar year. TEPB may deduct SO_2 allowances with a vintage year for the compliance period or a prior compliance period that are held in the enterprise's allowance account by the transfer deadline for the compliance period.

Compliance Timetable

The Taiyuan City SO_2 emissions trading program establishes several major compliance milestones for permitting, monitoring, establishing allowance trading accounts, and certifying compliance with emissions reduction obligations. The table in the Timeline section describes these major compliance deadlines in chronological order.

7. Enforcement

Determining Compliance

TEPB employs several approaches to monitor compliance with its environmental regulations, including:

■ *Self-Disclosure*. Each enterprise has responsibility for ensuring that it is in continuous compliance, it must report information to TEPB on a regular basis and inform the bureau if the it identifies an error or discrepancy.

TEPB will take measures to ensure the integrity of the emissions trading system and that real pollution reductions take place. These include the following:

■ *Inspections*. TEPB may conduct periodic inspections at enterprises. Inspections may be initiated on the basis of disclosures to TEPB, random selection, or by a variety of targeting methods. Staff may inspect facilities in order to evaluate operations, records, or other information.

■ *Reporting*. At the end of the reporting period each month, TEPB can import the submitted reports and manually enter the data for enterprises that do not have access to computers. When the emissions data and other supporting information are entered into the ETS, the software will automatically look for missing information or inconsistencies with previous reports by the enterprise. After all information is imported or entered, TEPB can use the ETS to create reports on enterprises' compliance.

Working with TEPB to Correct Violations

TEPB will work with enterprises to ensure the integrity of the emissions trading program. Enforcement decisions will take into account the degree to which the enterprise has anticipated problems and managed them. If an enterprise determines that it has knowingly or unknowingly violated one of the terms or conditions of the Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City or the Administrative Regulation on SO_2 Emissions Trading in Taiyuan City, it should bring that to the attention of TEPB. If it does not, and TEPB discovers violations through inspections or monitoring, the failure to come forward will be considered in calculating an appropriate penalty.

Consequences of Violations

If TEPB discovers a violation, it has several options. Selection of the appropriate enforcement response depends on the circumstances surrounding a particular event. TEPB is aware that violations can range from relatively minor errors in insignificant paperwork requirements to more major errors or even fraud relating to reporting or emissions reduction requirements.

Penalties

At the end of each year, if the actual emissions from an enterprise exceed the valid emissions allowances held by the source, TEPB will fine the enterprise at the rate of 3,000–8,000 yuan per ton of excess emission. The maximum penalty shall not exceed 30,000 yuan.

It is important that TEPB certify every trade made by the enterprises. Any emissions trading done by the enterprises without its certification will be disallowed, with a fine levied from 3,000 to 30,000 yuan per incident.

According to Rules on Punishment for SO_2 Over-Allowance Emissions in Taiyuan City, the source should pay its assessed penalty at the bank designated by TEPB, within one month of receiving the notice of the fine (see Annex 9). If the source fails to do this within the specified time, an overdue fine of 0.1% of the total punishment will be added every day. When a payment is more than one month late, the case will be enforced by the court.

8. Relation to Other Environmental Requirements

Enterprises are required to abide by all applicable existing rules and regulations. The enterprises participating in the Taiyuan City SO_2 emissions trading program are not exempt from other legal obligations of environmental protection (Article 6 of the regulation).

9. Trading Program Timeline

The following table provides a brief overview of the various processing deadlines critical to the operation of the trading program.

TRADING PROGRAM TIMELINE FOR A COMPLIANCE YEAR AND FOLLOW-ON ACCOUNTING PERIOD

Date	Event
January 1	Beginning of emissions reporting period
April 21	First quarter emissions report due to TEPB
July 21	Second quarter emissions report due to TEPB
October 21	Third quarter emissions report due to TEPB
December 1	TEPB holds allowance auction
December 21	TEPB distributes allowances to winning bidders at auction after payment is received
January 21	Fourth quarter emissions report due to TEPB with cumulative annual emissions statement
February 28	Deadline for allowance transfers for annual compliance purposes
March 1	Annual compliance certification report due to TEPB
March 31	TEPB provides compliance results and assesses penalties if necessary

10. Legal Status of this Guide

This guide tries to make clear what enterprises must do to comply with the applicable law and regulation. We hope you find this presentation of implementation rules useful and the additional information helpful in understanding the emissions trading program and reaching and maintaining compliance.

Enterprises that follow the steps set forth in this guide should be in compliance with Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City and the Administrative Regulation for SO_2 Emissions Trading in Taiyuan City. However, this is a new program and a learning experience for both TEPB and the enterprises. We urge you to bring any questions to TEPB promptly.

This is, however, only guidance. The actual rules are contained in *Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City and the Administrative Regulation for SO_2 Emissions Trading in Taiyuan City*. TEPB will update this guidance as it develops additional expertise with the emissions trading program, and new guidance may be at variance with this guidance.

Annex 1

Administrative Regulation on SO_2 Emissions Trading Program in Taiyuan City

See Appendix 10

Annex 2

SO_2 Allocation Scheme for Enterprises Participating in Emissions Trading in Taiyuan City in 2002–05

See Appendix 8

Annex 3

Certification of Authorized Account Representative and Alternate

Information of the Enterprise

Complete name	
Address	
Industry Code	
Information of the Authorized Account Representative (AAR)	
Name	Title
Address	
Tel	Fax
E-mail	

Level of authority

1st	2nd	3rd	Alternate representative
Other, please indicate:			

"I am authorized to make this submission on behalf of the owners and operators of [insert name of enterprise]. I certify under penalty of law that I have personally examined, and am familiar with, the statements and information submitted in this document and all its attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine."

Signature of AAR — Seal of the Enterprise

YY/ MM/DD — YY/MM/DD

Annex 4

Taiyuan City Trading Contract for SO_2 Allowance

Contracts between:

Purchasing side:	(Hereafter termed Side A)
Selling side:	(Hereafter termed Side B)

Supervisor:

Taiyuan City Environmental Protection Bureau (Hereafter termed Side C)

This contract is formulated for joint implementation in order to realize the city SO_2 total emissions control with minimal cost, strengthen management of SO_2 emissions allowances, and guarantee achievement of respective environmental targets and economic aims of the trading sides. The Rules are expected to be implemented by related units.

Traded content and price:

Valid time of the traded allowance:	Year
Amount of the traded allowance:	t
Unit price of the traded allowance:	yuan/t
Total payment for the traded allowance:	yuan

Common clauses:

The allowance sold by Side B must be effective SO_2 emissions allowance it holds.

After validation of this contract, Side B will transfer the ownership of SO_2 emissions allowance listed in the contract to Side A and Side A can only use the traded allowance during the valid time of the allowance.

Side A should pay the money for the allowance to Side B by bank account within 7 workdays after the signing and validation date of the contract.

This contract can be valid only after Sides A and B sign and seal the contract, and Side C verifies and files the trading, offering the certificate on Side B's holding of effective SO_2 emissions allowance and the certificate on the filing of this contract by Side C.

This contract is valid only before the use of traded allowance listed in the contract. During the validation time, either Side A or Side B can arbitrarily modify or dismiss the contract.

In case of dispute for the implementation of this contract, Sides A and B are to consult between themselves; otherwise, the both sides agree that _____ arbitration court committee should provide arbitration. (If no arbitration court committee is designated here and there are no written arbitration agreements for the dispute, they can take legal action to the People's Court.)

Purchasing side (Side A): (Seal)

Representative: (Seal)

Address:

Account bank:

Account number:

Telephone:

Selling side (Side B): (Seal)

Representative: (Seal)

Address:

Account bank:

Account number:

Telephone:

Supervisor (Side C): Taiyuan City Environmental Protection Bureau (Seal)

Representative: (Seal)

Address:

Telephone:

Signed on

_____ Y _____ M _____ D

Annex 5

Bidding Form for SO_2 Emissions Allowance Auction in Taiyuan City

Bidder:

Allowance amount to bid: t

Unit price for the allowance to bid: yuan/t

Quoting date: December , 20

Seal of the bidder

Annex 6

Application Form for Use of SO_2 Emissions Deposit in Taiyuan City

Application information:

Name of applicant:	
Year of use: 20	
SO2 emissions permit allowance in the year of use:	t
Purchased SO2 emissions allowance for the year of use:	t
Sold SO2 emissions allowance in the year of use:	t
Allowance deposit held at the end of the year of use:	t
Allowance amount applied for use in the current year:	t

Reason of application:

Applicant seal: Application date: 20 (Y) (M)

Suggestion of Taiyuan City Environmental Protection Bureau:

Taiyuan City EPB: 20 (Y) (M)

Annex 7

The Taiyuan Emissions Tracking System

The purpose of the Taiyuan emissions tracking system (ETS) is to collect, verify, and maintain data about mass emissions, fuel purchases, and production at the enterprises participating in the Taiyuan SO_2 emissions trading program. A variety of systems are currently used by various divisions of TEPB to estimate emissions for purposes of determining compliance with total emissions limits and for purposes of calculating the pollution levy. Results obtained from the various approaches differ widely, leading to different interpretations of the total emissions from a source. The ETS presents an unbiased estimate of actual emissions.

To ensure compliance with the emissions trading program, the TEPB must collect sufficient data to track and verify emissions from all units at each participating enterprise. While continuous emissions monitors (CEMs) are being installed at many of the larger sources of emissions, not all sources of emissions within the trading program will be measured by a CEM. The ETS will help TEPB collect, verify, and maintain data about SO_2 emissions, fuel purchases, and production at the enterprises.

Throughout each month, enterprises can use the ETS to enter information about changes in fuel inventories (e.g., beginning fuel inventory, fuel sales, fuel purchases, and fuel consump-

tion), characteristics of fuel (e.g., sulfur content), production levels (e.g., quantity of electricity produced), and measured emissions at each boiler. At the end of each month, the enterprise can export all the data to a file on floppy disk and submit it to TEPB.

At the end of the reporting period each month, TEPB can import the submitted reports and manually enter the data for enterprises that do not have access to computers. In addition, when the TEPB monitoring bureau inspects an enterprise, it can enter the monitoring data, including emissions concentration and emissions flow, into the ETS.

When the emissions data and other supporting information are entered into the ETS, the software automatically searches for missing information or inconsistencies with previous reports by the enterprise (e.g., if the enterprise emitted 4 tons of SO_2 per unit of production in one month and only 1 ton per unit of production the next). After all data is imported or entered by TEPB, staff can use the ETS to create a report that identifies all boilers and enterprises with missing data, inconsistencies, or no reported emissions.

The ETS can create various reports, such as all data reported by an enterprise for a specific month, and all data reported by an enterprise for each month from a beginning to end date.

In addition, the ETS will allow TEPB to export a summary of emissions for a specified period, including enterprise account number, enterprise name, and reported emissions. TEPB can use this exported file with the allowance tracking system to judge compliance.

Annex 8

Quarterly Report Form of SO_2 Emissions Source in Taiyuan City

Source Name: Time during reported: Month Year Month Year

Emissions Situation:

No. Stack: **Position:**

Measurement method: Material balancing

Stack Height (m)	**Total Emission (t)**		**Boilers**				
	Fuel burning	Process	Fuel type	Fuel consumption (t)	Fuel sulfur content (%)	Emission (t)	Operation time (month)
			Boiler 1				
			Boiler 2				
			Boiler 3				

Measurement method: Continuous on-line monitoring

Emission: t

Note:

1. The numbers of stacks should be in accordance with normalized numbers by city EPB. Copies can be made to fill for multiple stacks.
2. Sources with continuous on-line monitoring equipment only fill in on-line monitoring data.

3. Measurement methods for the stacks should be based on stipulation of city EPB.
4. Sources based on material balancing must provide receipt invoices for borrow of the fuels and copies of Sulfur Content Test Report. Those based on continuous on-line monitoring must provide raw data of continuous on-line monitoring.

Reported by: _____ Report date: _____ Seal of the source:

SO_2 Emissions Statement of Pollution Source in Taiyuan City

1. Source name:

2. Report year:

3. Permit allowance of the year: (t)

4. Actual emissions in the year:

Total emissions in the year: t	**Total fuel consumption in the year: t standard coal**	
	Average sulfur content of the fuel: %	
Stack 1 emission: t	Stack 2 emission: t	Stack 3 emission: t
Stack 4 emission: t	Stack 5 emission: t	Stack 6 emission: t

5. Emissions trading situation in the year:

Selling

Amount: t	Sell to:	Date: M / D
Amount: t	Sell to:	Date: M / D
Amount: t	Sell to:	Date: M / D
Amount: t	Sell to:	Date: M / D
Amount: t	Sell to:	Date: M / D

Buying

Amount: t	Buy from:	Date: M / D
Amount: t	Buy from:	Date: M / D
Amount: t	Buy from:	Date: M / D
Amount: t	Buy from:	Date: M / D
Amount: t	Buy from:	Date: M / D

6. Deposited allowance held at the end of the year: t

If this deposited allowance used in this year or not?

Reported by: Checked by:

Report date: Seal of the source:

Annex 9

Punishment Note for SO_2 Over-Allowance Emission in Taiyuan City

_____:

Verified by our bureau, the actual SO_2 emission of your organization in 20__ is _____ t, and the effective emissions allowance held at the end of the year is _____ t (emissions permit allowance + emissions trading allowance + use of deposited allowance). The actual SO2 emission from your organization thus exceeds the effective emissions allowance. According to the Administrative Regulation for SO_2 Emissions Trading in Taiyuan City, the part of actual emission over the effective emissions allowance (_____ t) is fined with a rate of _____ yuan/t. The total amount of punishment is: _____ yuan.

It is expected that your organization pay the above money to SO_2 Emissions Trading Administrative Center of city EPB through the bank within 5 workdays after receiving the note. If you fail to do this within limited date, related regulations will be observed and followed.

Contact information of SO_2 Emissions Trading Administrative Center, Taiyuan EPB:

Address: _____

Telephone: _____

Bank account: _____

Contact person: _____

SO_2 Emissions Trading Management Center,
Taiyuan Environmental Protection Bureau

(Y) / (M) / (D)

APPENDIX 10

Administrative Regulation on SO_2 Emissions Trading in Taiyuan City

(Issued by Taiyuan City government on October 4, 2002)

1. This Regulation is formulated in accordance with *Law of Air Pollution Prevention and Control of People's Republic of China* and *Administrative Regulation for Total Emissions Control of Air Pollutants in Taiyuan City* and consistent with actual situation in Taiyuan city, in order to protect and improve the air environmental quality, realize total emissions control of SO_2 with minimal cost, and promote coordinative development of environment and society and economy, through SO_2 emissions trading program.

2. SO_2 emissions trading means the SO_2 emissions allowance trading between polluters under the premise of total emissions control (TEC).

3. This Regulation applies to all the polluters that emit SO2 in the administrative districts of Taiyuan.

4. SO_2 emissions trading target under the TEC target shall abide by the rules of market economy, carry out compensated transfer under the guidance of the government.

5. The city environmental protection department performs overall supervision and management for SO_2 emissions trading. Other departments, such as planning, economic, legal, financial, and pricing ones, shall cooperate for the work in SO_2 emissions trading.

6. The polluters who participate in SO_2 emissions trading shall not be exempted from other legal obligations of environmental protection.

7. The environmental protection department shall, in accordance with the SO_2 TEC targets and allowances planned by national and provincial government, formulate the city's own SO_2 TEC targets and annual SO_2 abatement plan.

8. The allocation of SO_2 emissions allowances is performed by city environmental protection department in accordance with city SO_2 TEC and approved by city government before dispatched to related polluters in the first year of a Five-Year Plan period.

9. One SO_2 emissions allowance in annual SO_2 emissions allowance allocated to each polluter by city environmental protection department means the emission of one ton of SO_2.

10. In case of reductions in SO_2 emission because of conversion to central heating, plant shutdown, merger, relocation, and bankruptcy of enterprise, etc., city environmental protection department shall take back or adjust the emissions allowance of the polluters.

11. The reconstruction, expansion, merging, and splitting in existing enterprises shall not result in additional SO_2 emissions allowances. New sources can obtain annual emissions allowance through trading or be allocated SO_2 emissions allowances in the next Five-Year Plan period.

12. The SO_2 emissions allowances held by polluters can be traded and deposited. The emissions allowances cannot be used ahead of scheduled time.

13. The polluters with allowance deposits shall fill *Taiyuan City Application Form for Usage of SO_2 Allowance Deposit* and submit it to environmental protection department when they want to use them. The deposited allowances can only be used after verification by the environmental protection department.

14. The trading of emissions allowances shall abide by the Voluntary Principle. SO_2 emissions trading adopts the form of bilateral agreement based on the cost of abatement and the market situation. The two sides achieving intention of trading shall sign *Taiyuan City SO_2 Emissions Allowance Trading Contract*, which shall be ratified and kept for record before put into effect.

15. The allowance that is taken back or changed because of implementation of Article 10 of this Regulation shall be auctioned by the city environmental protection department. The detailed procedure of this Regulation shall be formulated by city environmental protection department.

16. The polluters can obtain emissions allowances through contending auction. The earning from auction shall be submitted to local government and used for improving air quality.

17. The actual annual SO_2 emission of one polluter shall not exceed the SO_2 emissions allowance held by the polluter at the end of the same year.

18. The responsibilities of city environmental protection department include establishing specified SO_2 Emissions Tracking System (ETS) and Allowance Tracking System (ATS), setting up SO_2 emissions accounts, tracking the allocation and trading of emissions allowances, and publishing the information and reference price of SO_2 emissions trading on a regular basis.

19. The polluters should install Continuous Emissions Monitoring (CEM) equipment, so as to accurately measure the actual SO_2 emissions and regularly send the data to the Municipal Environmental Monitoring Center.

20. The polluters shall fill *Quarterly Report Form of SO_2 Emission* at the end of each quarter and *SO_2 Emissions Statement* for the last year before January 15 each year in line with the realities, and submit it to city environmental department for approval.

21. The polluters shall apply to city environmental protection department and go through necessary procedure 30 days in advance if they want to alter SO_2 emissions abatement technologies. No explicit reply from the environmental protection department within 20 days after the polluters submitted their applications will be treated as agreement to the alteration.

22. In March every year, the city environmental protection department publishes *Taiyuan City SO_2 Emission and Emissions Trading Checklist* based on sum-up and verification of *SO_2 Emissions Statements* and *Taiyuan City SO_2 Emissions Allowance Trading Contracts* of polluters in the whole city, and publishes the situation of SO_2 emissions and emissions trading.

23. If the polluters' actual annual SO_2 emission exceeds the SO_2 emissions allowance they hold at the end of the same year, they shall be fined by environmental protection department 3,000 to 8,000 yuan per ton of excess emission, and the maximum penalty shall not exceed 30,000 yuan.

24. The emissions trading done by the polluters themselves without the certification of the environmental protection department shall be regarded as ineffective. The two trading parties shall be fined 3,000 to 30,000 yuan by environmental protection department.

25. The polluters violating other articles of this Regulation shall be punished by environmental protection responsible department in accordance with relevant laws and regulations.

26. The law enforcement officials in the environmental protection department, if committing malpractice, misuse of authority, or self-seeking misconduct, shall be given administrative punishment by their own agencies or the responsible departments at higher levels. For those who commit crimes, criminal liabilities shall be pursued.

27. The concerned agents can apply for administrative reconsideration or sue for administrative lawsuit according to laws and regulations if they refuse to accept the administrative punishment as final.

28. The interpretation of this Regulation shall be the responsibility of city Government, and the implement of this Regulation shall be the responsibility of environmental protection department.

29. This Regulation shall enter in force 30 days after it is promulgated.

■ ■ ■

APPENDIX II

Contacts for Shanxi and Taiyuan March 2001 through June 2003

Shanxi Development and Planning Commission

Lan Guangdong	Vice Chairman
Zeng Xianqi	Director of Foreign Capital Utilization Dept.
Wu Dongsheng	Vice Department Director and senior Economist
Zhang Rongzhang	Vice Director of Environmental Protection Department
Xi Zhiwen	Vice Department Director

Shanxi Environmental Protection Bureau

Wang Shujing	Director
Du Peiren	Deputy Director
Liu Silong	Deputy Director
Lu Buyun	Vice Director of Foreign Affairs Office
Cao Guilu	Professorate Senior Engineer
Qu Zhongrang	Vice Director of Planning and Finance Department
Cui Yu	Foreign Affairs Office
Zhao Luying	Engineer
Wang Xingnan	Senior Engineer
Li Shaojing	Senior Engineer
Wang Jinglong	Director of Pollution Control Department
Zhang Xiaodong	Vice Director of Pollution Control Department
Zhang Shutang	Development Department
Qiao Huilin	Vice Director of Pollution Control Department
Fan Rui	Pollution Control Department
Wan Aiyun	Senior Engineer

Taiyuan City Government

Rong Tong	Deputy Mayor
Shang Atao	Vice Secretarial

Taiyuan Planning Commission

Liu Jihong	Division Director
Hao Xuegong	Vice Director and Senior Economist
Zhang Chi	Vice Division Director
Zhao Chunsheng	

Taiyuan Environmental Protection Bureau

Liang Liming	Director
Ge Xinwen	Deputy Director
Jiang Qiujing	Senior Engineer
Zhang Xiufeng	Director of Technology Division
He Mei	Director of Law and Regulation Division
Xie Yuqi	
Chen Jiguang	Director of Planning and Finance Division
Zhang Zhijie	Vice Director of Planning and Finance Division
Zhao Li	Planning and Finance Division
Xu Demao	Director of Air Quality Division
Zhang Haijun	Law and Regulation Division
Yu Shuang	

Taiyuan Environmental Monitoring Center

Wang Huiwen	Director
Zhang Hua	Senior Engineer
Wang Zhizhong	Vice Chief Engineer

Taiyuan Environmental Inspection Station

Wu Yuanyuan	Vice Director

Taiyuan Coal Gasification Company

Wang Yumo	Senior Engineer and Director of Environmental Section
Zhang Yali	Division Chief of Environmental Section
Wang Zhaowen	Senior Engineer and Chief Engineer
Wang Liang	Division Chief of Environmental Section of Coking Plant
Yang Ling	Chief Engineer
Zhang Aixin	Vice Manager
Guo Yanyun	Vice Division Chief of Environmental Section
Han Shuanzhu	Party Secretary and Senior Engineer

Taiyuan Power Plant 1

Zhou Maode	Vice Manager
Hao Qiang	Director of Environmental Protection Office
Chen Zhiqing	Environmental Protection Office

Taiyuan Power Plant 2

Zhang Bin	Environmental Protection Division

Taiyuan Iron & Steel Group Company

Liu Fuxing	Vice General President and Senior Engineer
Guo Juncai	Chief of Environmental Protection Section and Senior Engineer
Hao Weihong	Foreign Affairs Office Director
Liu Yaojun	Director of the Environmental Monitoring Station
Huang Wende	Manager of Coking Plant
Li Jishan	Chief Engineer of Power Generation Plant
Guo Shaohua	Division Director of Environmental Protection Section

Taiyuan Zhonglu Environmental Protection Company

Bai Mingcheng	General Manager

Heating Supply Division of Taiyuan Railway Bureau

Liu	Director of Heating Division
Liu	Chief of Environmental Office
Wang	Engineer of Environmental Office
Ji Rongbin	Director of Foreign Affair Office

Taiyuan Heating Supply Company

Ma Guocheng	General Manager
Li Ning	Party Secretary
Gao Zhigang	Vice Manager
Zhao Zhihu	Vice Manager

Coking Plant of Taiyuan Chemical Industry Company

Shan Mancheng	Director of Environmental Division

Taiyuan Gangyu Dongshan Power Plant

Pin Kerui	Chief Engineer

Xishan Coal and Power Group Company

Zhang Zhanmin	Environmental Protection Division

Taiyuan Heavy Machinery Making Group Company

Zhang Yaohong
Liu Yan

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