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In This Issue

With this Summer 2002 issue, we are pleased to bring back the Sinosphere Journal after a two-year hiatus. During that time, China has vaulted onto the global stage through such developments as its entry last fall into the WTO and its capture of the 2008 Olympic Games. Under the leadership of Editor-in-Chief Feng An, an energetic group of authors, editors and correspondents has worked tirelessly to document for you China's latest environmental trends and developments during this exciting time.

The issue opens with an overview of the China Sustainable Energy Program (CSEP) by CSEP Director Doug Ogden and Senior Program Associate Patty Fong. The article highlights a number of promising new initiatives designed to catalyze China's energy efficiency and renewable energy technology markets.

As a follow-up to a PACE seminar held at the World Bank last March, this issue focuses on the theme of new approaches to emission control in China. The first feature essay by Jintian Yang and Stephanie Benkovic summarizes the results of a strategic collaboration between China's State Environmental Protection Administration and the U.S. Environmental Protection Agency to study the feasibility of using market mechanisms, most notably emissions trading, to achieve sulfur dioxide emission reductions in China.

The second feature essay, by Barbara Finamore, Paul Hibbard, Nancy Seidman and Tauna Szymanski, explores China's experimentation with the use of output-based standards to reduce power plant emissions while improving efficiency. Next, Jia Li, David Streets, Sarath Guttikunda, Gregory Carmichael, Young-Soo Chang and Virginia Fung illustrate through cost-benefit analysis that investments in clean energy and air pollution controls could have significant health benefits for developing cities like Shanghai. Finally, Patrick Mulcahy presents a case study on the development of a new coal-fired power plant utilizing advanced pollution control technology.

Zhu Weisi and Nuyi Tao round out the issue with briefings from the NPC and CPPCC as well as general environmental news. Thomas Shen also provides a thorough report on the April 2002 United Nations Forum in Beijing on "New and Emerging Technologies and Sustainable Development."

We thank everyone who has written to express their support for continued publication of the Sinosphere Journal, and look forward to your comments and suggestions for future topics and themes.

Editorial Board
Sinosphere Journal

Spotlight On China

The China Sustainable Energy Program: An Overview

Doug Ogden and Patty Fong[1]

China's deteriorating air quality from fossil fuel combustion has serious ramifications for China's public health and economic prosperity, and clear global import as well—China's carbon emissions are on a trajectory to surpass the U.S. in two decades. China's central planners are shifting to competitive markets with lightning speed, and are developing the economic policies today that will shape the technology choices of the world's most populous nation for the next several generations.

With these challenges in mind, the David and Lucile Packard Foundation and the Energy Foundation together launched the China Sustainable Energy Program (CSEP) in March 1999. The Packard Foundation provides $5 million per year in program support, and the Energy Foundation provides program management. The program was built on a decade of cooperation between senior Chinese energy policy officials and the Lawrence Berkeley National Laboratory (LBNL) in the U.S., as well as extensive field interviews and strategic planning workshops with senior Chinese energy policy officials. The program principally funds Chinese energy policy NGOs and research institutes affiliated with central, provincial, and local government agencies, as well as international policy practitioners who introduce "best practice" energy efficiency and renewable energy policies to their Chinese counterparts. The program's goal is to assist Chinese NGOs, research institutes, and their affiliated government agencies to develop and implement public policies that can attract energy efficiency and renewable energy technologies to China's burgeoning marketplace.

The first grants included support for (1) appliance efficiency standards, (2) building energy codes, and (3) long-term "low-carbon" policy analytic scenarios. Since 1999, the program has expanded to include programs in (4) industrial energy efficiency, (5) electric utilities, (6) renewable energy, and (7) transportation.

We opened a Beijing office in 1999, which now has nine full-time native Chinese staff overseeing grants, workshops, and policy initiatives in all program areas.

The projects are organized around specific programmatic strategies, which have been developed in concert with senior government officials charged with overseeing energy policy development in their sectors. The projects benefit from the active guidance of two senior governmental advisory groups, the "Senior Policy Advisory Council" (PAC) and the "Dialog Partners" group, which both meet periodically. All projects include an international "best policy practices" component; international policy experts work closely with their Chinese counterparts and jointly develop energy efficiency and renewable energy policy analyses and policy recommendations, and participate in inter-ministerial meetings and workshops.

Now in its fourth year, the program aims, in time, to measure its progress through actual energy savings (through the deployment of new energy efficiency technologies) and new renewable energy megawatts. Early projects have focused at the central government level, although as policies grow in acceptance in Beijing, we are increasingly shifting toward supporting provincial implementation projects. Local projects are underway in all program areas.

Highlights

With over 60 projects underway, we are seeing significant policy development progress in all program areas—including new national and provincial policies.[2] In time, these policies promise to spur markets in energy efficiency and renewable energy technologies.

Transportation. China's vehicle fleet is growing at a staggering 20 percent every year, oil imports have topped 30 percent, and national oil security is a hot concern of the State Council (cabinet). Vehicles cause the majority of air pollution in most large cities. CSEP supported Chinese grantees with strong State Council and State Economic and Trade Commission (SETC) access to form an inter-ministerial steering committee and working group aimed at developing, for the first time in China, a comprehensive package of **vehicle fuel economy**

[1] Doug Ogden is Executive Vice President of the Energy Foundation and Director of the China Sustainable Energy Program. Patty Fong is the Senior Program Associate with the Energy Foundation.

[2] A full list of CSEP grants, grantees, and grant guidelines by sector is available online at <http://www.efchina.org>.

policies and standards.[3] A package of mandatory standards, labeling and reporting regulations and incentives is now on the fast track, to be phased in over five years. Fuel economy test protocols developed by grantees in 2001 have already been adopted. The grantees are now drafting fuel economy regulations, labeling conventions, and supporting fiscal policies. Over the next two years, grantees expect to have the first of these regulations in place. In addition to directly reducing greenhouse gases, stringent fuel economy standards coupled with grantee efforts to ratchet in strong emissions limits and fuel quality standards will increasingly move China toward clean and efficient advanced technology vehicles.

China's Ministry of Science and Technology approved a **$100 million R&D program** to develop advanced hybrid-electric drive and fuel cell vehicles. Several grantees helped develop some of the technical and policy analyses that contributed to the development of this program.[4]

Implementation of strict fuel efficiency standards will not be easy. With WTO accession, China is concerned about the weak competitive position of its domestic auto industry, and so is cautious about aggressive standards that might further weaken that position. To address these concerns, the grantees are convening inter-ministerial meetings to build a policy consensus, bolstered by analyses that demonstrate the net benefits of adopting aggressive fuel economy and emissions standards. We find there is increasing resolve among senior leaders to push these policies due to serious concerns about growing oil imports.

Appliance Efficiency Standards. China produces more light bulbs, refrigerators, air conditioners, washing machines, TVs, and other consumer appliances than any other country—and growth is exploding. The energy consumption of these appliances far exceeds world standards. Standards and labels on just four appliances (refrigerators, air conditioners, TVs, and clothes washers) promise to avoid roughly *nine percent* of China's residential electricity needs in 2010. Grantees efforts on three standards to date (fluorescent lamps, clothes washers, and TVs) could displace ten large (500-megawatt) power plants by 2010.[5]

A significant new policy development involves **"standby power" in TVs**. Many appliances, while turned "off," require electricity; for example, any appliance with a remote control, and any with a transformer in the wall plug. Standby power losses amount to about 10 percent of the electricity consumed in most U.S. residences, and a similar percentage in Chinese urban residences. One year ago, the standby power issue was largely unknown in China. At the behest of the China National Institute of Standards and LBNL, CSEP sponsored government officials to attend an international conference on the topic, convened several subsequent workshops, and in January 2002 China announced it will pursue a national standard cutting standby power by 90 percent. Chinese manufacturers are already producing TVs with a microchip that cuts standby consumption (a $1 retrofit) and are being awarded an "energy star" label for use in marketing TVs that meet the standard. Over the coming years, CSEP will continue to support the development of appliance standards, targeting those with the greatest carbon emissions savings potential first.

Building Codes. China's decade-long building boom has been the fastest and most expansive in human history. Already, buildings consume a quarter of China's total energy. Almost none of these buildings were built to the standards of an energy code. But this is beginning to change. Three years ago, CSEP supported the launch of two new Chinese NGOs[6] that developed, with technical support from LBNL and the Natural Resources Defense Council (NRDC), a new **national residential building code** aimed at slashing 50 percent (from 1989 levels) of the energy consumed in new residential buildings in sixteen provinces in Central China (along the Yangtze River). The grantees are similarly developing China's first national commercial building code.[7] Stringent codes promise to usher a host of energy efficiency equipment and building materials into China's markets.

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[3] Chinese grantees: Tsinghua University, China Automotive Technology and Research Center (CATARC), and the State Council Development Research Center (DRC); international consultants: Michael Walsh, Michael Wang, Feng An.

[4] Chinese grantees: CATARC, Northern Jiaotong University Institute of System Engineering; international consultants: Michael Walsh, Michael Wang, Feng An.

[5] Chinese grantee: China National Institute of Standardization (CNIS); international consultant: Lawrence Berkeley National Laboratory (LBNL).

[6] Chinese grantees: China Building Energy Efficiency Association (CBEEA), China Academy of Building Research (CABR); international consultants: LBNL, Natural Resources Defense Council (NRDC).

[7] Chinese grantee: CBEEA; international consultant: LBNL.

The challenge now is to translate national codes into local building practices. There is no experience at the local level in integrating energy code performance criteria into building practices. Grantees[8] are focusing going forward on local implementation incentives and enforcement mechanisms in Central China so that the target—cutting 50 percent of building energy consumption—becomes practice

Renewable Energy. China has some of the world's richest wind resources and could in theory power itself more than twice over with wind energy alone. Recognizing this potential, the central government is considering grantee recommendations[9] for a national **"renewable portfolio standard"** (or "mandatory market share" provision), which is noted in the Tenth Five-Year Plan and calls for over five percent of China's electricity to come from renewable energy by the end of this decade. The first implementation step is a **"wind concession"** program in two provinces, whereby wind energy developers will be auctioned exclusive access to a wind resource in return for developing wind electricity.[10] Over the next two years, while working with the World Bank and other international funding partners, CSEP will support program policy design and implementation, with the goal of helping China catalyze a utility-scale wind energy industry.

Electric Utilities. China's electric utilities are the single largest source of air pollution in the nation. They consume nearly half of China's coal. Three-quarters of China's electricity comes from aging coal-fired power plants. Most of these belong to a single unregulated state-owned enterprise. Two years ago, China's State Environmental Protection Administration (SEPA) approached CSEP seeking a policy mechanism to implement the "Total Emissions Control" provisions of China's Air Quality Law. CSEP supported Massachusetts officials to train the China Research Academy of Environmental Sciences (affiliated with SEPA) on **"generation performance standards" (GPS)**, which regulate power plant emissions on an electricity production basis. GPS creates an incentive to both reduce emissions and improve the efficiency of thermal power plants, shifting generation investments toward cleaner resources. SEPA has now launched four provincial GPS pilots—in Zhejiang, Jiangsu, Shandong, and Shanxi—with CSEP support.[11]

China has no regulatory structure overseeing its power sector, and as a result, China's utilities are far less efficient and far more polluting than the developed country average. Three years ago, CSEP grantees launched an "Electric Utility Sector Comprehensive Reform" project aimed at developing a consensus among China's senior ministries on the direction of power sector reforms. CSEP convened more than a dozen inter-ministerial workshops and supported eight ministries and their affiliated research institutes to draft separate chapters of a Comprehensive Reform Plan.[12] In January 2002, the State Council issued a decree launching new power sector reforms, including a **"national regulatory commission"** that will oversee reforms and incorporate demand-side energy efficiency and renewable energy into power sector regulations. CSEP grantees are now helping to design regulatory institutional structures that can promote energy efficiency and renewable energy at the central, regional, and provincial levels.[13]

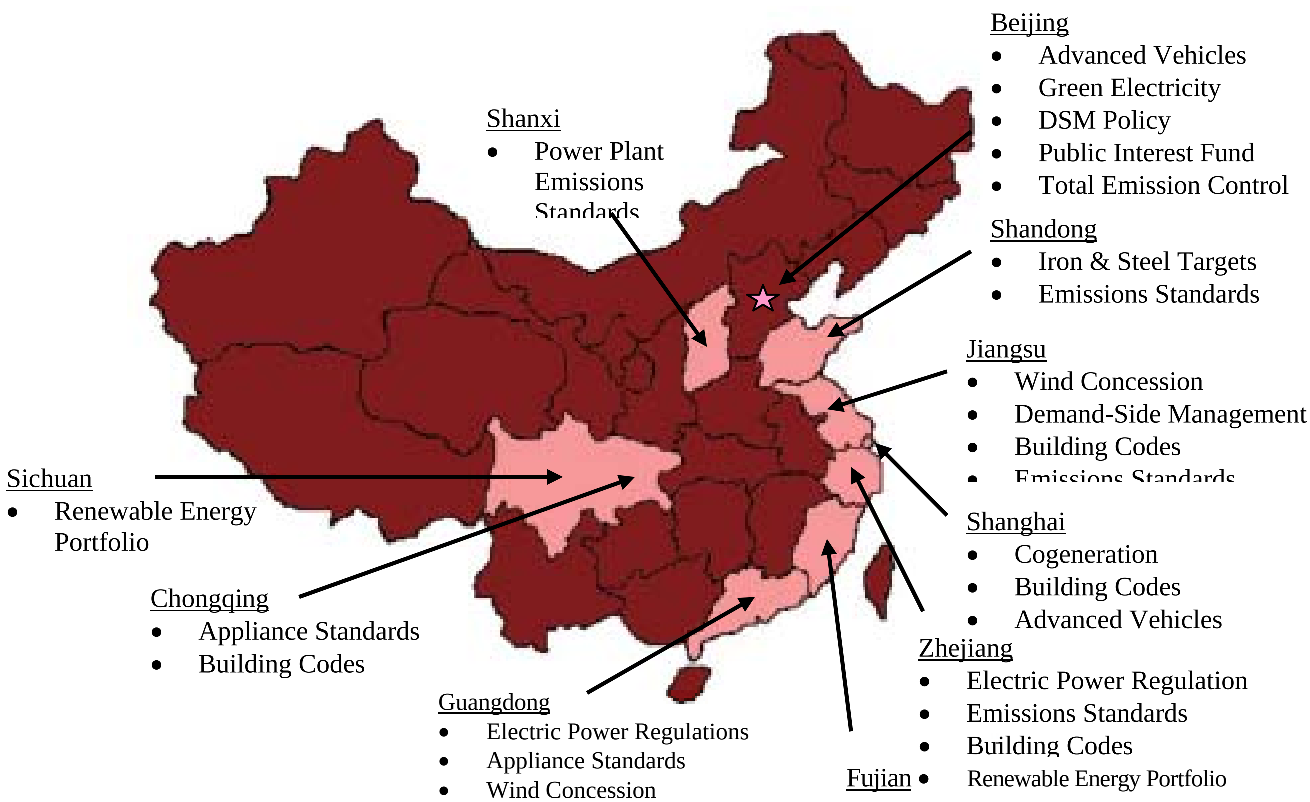
The Challenges Ahead

In future years, we will increasingly support policy pilots in the provinces to demonstrate on the ground the substantial energy savings to be gained from national energy efficiency and renewable energy policy progress. To date, we have been asked by the central government for assistance with 25 provincial pilots, noted on the map (see next page).

Provincial and local work is challenging. China's central government policy priorities may not parallel local priorities. Local sustainable energy policy nstitutions are in their nascence. Going forward, we aim to support energy policy organizations in the

[8] Chinese grantees: CBEEA, CABR; international consultants: NRDC, LBNL.
[9] Chinese grantee: Center for Renewable Energy Development (CRED); international consultant: Center for Resource Solutions (CRS).
[10] Chinese national-level grantee: CRED; provincial grantees: Guangdong Techno Economic Research Center, Jiangsu Energy Conservation Center; international consultant: CRS.
[11] Chinese grantee: China Research Academy for Environmental Sciences (CRAES); international consultants: Regulatory Assistance Project (RAP), Nancy Seidman, Paul Hibbard, NRDC. (*Editors Note: see related article on page 13).*
[12] Chinese grantees: State Council Development Research Center (DRC), CRAES, CRED, Beijing Energy Efficiency Center, State Power Economic Research Center, State Power Corporation, Chinese Academy of Social Sciences, State Development Planning Commission Market and Price Research Institute; international consultant: RAP.
[13] Chinese national-level grantee: Institute of Economic System and Management of the State Council Office of Restructuring the Economic System; provincial grantee: Zhejiang Energy Research Institute; international consultant: RAP.

provinces that can provide regional, provincial, and local policy analytic capacity for local policy development. We will work to identify local policy priorities in concert with the central government, provincial governors, and local mayors, with the aim of spurring local momentum for new clean energy technology policies. The grantees are confident that these policies, accompanied by high-level and local decision-maker support, will help shape transparent market rules and catalyze energy efficiency and renewable energy technology markets—thereby mitigating the public costs associated with fossil fuel combustion.



Featured Essays - New Approaches for Air Pollution Control

The Feasibility of Using Cap and Trade to Achieve Sulfur Dioxide Reductions in China[1]

Jintian Yang[2] and Stephanie Benkovic[3]

Executive Summary

This study explores the feasibility of using emissions trading in China to achieve reductions in sulfur dioxide (SO_2) emissions. It was developed through a multi-year collaborative process that examined lessons learned from the United States (U.S.) SO_2 emissions trading program and considered their implications for China. The U.S. and China have both identified emissions of SO_2, and associated secondary particles, as damaging to human health, lakes and streams, forests, buildings, monuments and visibility. The U.S. has successfully used emissions trading, a market-based mechanism, in concert with an emissions cap to reduce SO_2 emissions at least cost. China is investigating policies that will meet the dual goals of promoting economic development and protecting public health and the environment. Based on this mutual interest, a strategic collaboration was initiated between China and the U.S. On April 9, 1999, China's State Environmental Protection Administration (SEPA) and the U.S. Environmental Protection Agency (EPA) signed a Statement of Intent to prepare a feasibility study on the use of market mechanisms to achieve SO_2 emission reductions in China.

Background

Controlling SO_2 in China

SO_2 emissions in China are produced at numerous large and small stationary sources, primarily as a result of coal-fired boilers for producing electricity or running other industrial and commercial processes. Sources of emissions in China include a wide variety of enterprises such as power plants, cement manufacturers, and other small industrial enterprises. Based on current estimates, approximately 40 percent of all SO_2 emissions in China are related to power production.

In 2000, SO_2 emissions in China reached nearly 20 million tons. Approximately 70 percent of cities in southern China are exposed to acid rain, representing approximately 30 percent of China's landmass. These figures suggest that China has become one of the three largest acid rain regions in the world. According to estimates from the Chinese Research Academy of Environmental Sciences, the total economic loss stemming from SO_2 pollution and acid rain totaled 110 billion yuan (approximately $13.3 billion) in 1995, close to 2 percent of China's Gross National Product that year.

The Chinese government has attached great importance to the control of SO_2 and has adopted a series of control measures. These measures include the designation of "two-control zones" (one focused on high levels of acid precipitation and the other on high ambient SO_2 concentrations) and a pollution levy fee on SO_2 emissions. In addition to these measures, China has formulated a set of technology policies related to SO_2 emissions, such as restricting the use of high sulfur-content coal, requiring coal washing, and employing flue gas desulfurization.

The cornerstone of recent Chinese air quality policy is the Total Emissions Control (TEC) program. The TEC program specifies a national SO_2 emission target and allocates the target to the Provincial and municipal levels. China's "Tenth Five-year Environmental Protection Plan" set the TEC limit at 10 percent below 2000 emissions levels nationwide and 20 percent below 2000 levels in the two control zones. These reductions must be met during the Tenth Five-Year Plan period (2001-2005).

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[1] This article is taken from the Executive Summary of a larger report for a project initiated in 1999 under the US-China Forum. Numerous experts from China's State Environmental Protection Administration (SEPA), the Chinese Research Academy of Environmental Sciences (CRAES), and the United States (U.S.) Environmental Protection Agency (EPA) participated in workshops and contributed to this report. Other notable collaborators include the Massachusetts Institute of Technology, ICF, and RAND. Pilot projects developed by EDF and RFF also helped illuminate key issues for this Study.

[2] Chinese Research Academy of Environmental Sciences (Mr. Yang is the leader of the Chinese team for the Feasibility Study).

[3] U.S. Environmental Protection Agency (Ms. Benkovic is a Senior Policy Analyst in EPA's Clean Air Markets Division. She is the lead staff on the Feasibility Study for the U.S.)

The structure of the TEC policy, which includes setting national emissions limits, could form the foundation for a "cap and trade" program. A strictly managed total cap on emissions is a necessary basis for an emissions trading program, and an effective cap will ensure that the environmental goal is met. The use of emissions trading helps ensure that emission reductions are made cost effectively, since trading encourages reductions where they are least costly. Experimentation with pilot projects in the 1990's gave China some experience with the potential benefits of emissions trading. The TEC policy, combined with improved management capacity, an evolving market economy and new environmental requirements suggest China may be ready to formally embrace emissions trading.

The Use of SO_2 Emissions Trading in the U.S.

The U.S. has successfully used a cap and trade program to cost-effectively reduce SO_2 emissions from large electricity generating sources. A cap and trade program sets an overall emission limit for power plants (the cap) and harnesses the power of the market (trading) to achieve desired environmental results at lower costs. More than 6 million tons of SO_2 have been reduced from sources affected by the program during a period of rapid economic growth. Cost estimates for achieving the full 8.5 million ton reduction goal have decreased dramatically from original estimates. The success of the U.S. SO_2 trading program has led to the application of cap and trade to reduce emissions of oxides of nitrogen (NO_x) in the Northeastern U.S. states. More recently, the U.S. has proposed using cap and trade to further limit emissions of SO_2, NO_x and mercury emissions from power plants.

The U.S. experience has shown that a cap and trade system can produce cost-effective SO_2 emissions reductions. How well future cap and trade programs work in China or other countries will be a function of the underlying design elements of the program and the strength of the infrastructure supporting them. Key lessons learned in the U.S. that may be transferable to China include:

- *Design*. Several overarching principles—simplicity, accountability, transparency, predictability, and consistency—should guide the development of a cap and trade program. Adhering to these principles can promote compliance and an efficient emissions trading market.

- *Infrastructure*. Institutions and incentives needed for the trading market to function include a system of private contracts and property rights, at least a partially profit driven private sector or cost minimizing enterprises, and respect for the rule of law.

- *Data accuracy*. It is critical to have accurate, consistent, complete and transparent emissions information. This ensures both environmental credibility and economic efficiency.

- *Data tracking*. An efficient system for managing and tracking emissions and allowance data will facilitate administration of the program, enhance market operations, and reduce errors.

- *Compliance and enforcement*. As with all environmental programs, a cap and trade program requires effective enforcement to ensure that environmental and cost-savings objectives are met. For an emissions market to develop there must be confidence that emissions will be correctly measured and reported, that compliance will be verified, and if there is noncompliance, that a penalty significantly greater than the cost of compliance will be assessed.

There are, of course, some noteworthy differences between China and the U.S. China's economic, political and policymaking systems differ in many ways from those in the U.S. China and the U.S. also differ in their use of pollution control technologies, environmental management techniques and experience with private markets. Such differences must be taken into consideration when introducing SO_2 emissions trading in China.

Key Findings

The use of emissions trading to achieve SO_2 reductions in China is feasible. Several factors lead to this conclusion. The environmental nature of the problem, the potential cost savings from trading and the current improvements in infrastructure all provide optimistic signs for the use of emissions trading in China. However, significant barriers still exist need to be addressed before emissions trading could be effectively used on a large scale in China. These issues are explored below.

A Cap and Trade Structure is Appropriate to Address China's SO_2 Problem

Acid rain and SO_2 problems in China are regional in nature. Therefore, the use of cap and trade, which allows some flexibility in where emissions occur, is an appropriate policy tool. Cap and trade mechanisms are most effective when they address emission reductions over a large geographic area.

Sources Have A Range of Marginal Control Costs

There are a wide variety of marginal control costs among SO_2 emitting sources in China i.e., different costs for different enterprises. Marginal control cost differences result from the age of the facility, technology availability, location, fuel use and other factors. Since a wide range in marginal control costs exists in China, an emissions trading program can help find the least cost approach for the participating sources. (Sources with low compliance costs typically over-comply and sell their excess reductions to sources with higher compliance costs.) From the perspective of the power industry, establishing a national market for emissions trading is feasible because it should help level disparities between different thermal power plants in pollution abatement costs.

Infrastructure for Cap and Trade is Beginning to Form in China

While still far from complete, the infrastructure necessary to support a cap and trade program is beginning to emerge in China. China has already begun experimenting with pilot emissions trading projects. In 2000, China revised its Air Pollution Control Law to provide legal authority for the TEC policy, which establishes an emission target (like a cap) for SO_2. The State Environmental Protection Administration is currently developing administrative regulations to implement the TEC policy that will include language on emissions trading. Provisions in related laws go further in building the fundamentals for emissions trading through the creation of pollution permits. In 1997, standards requiring the installation of continuous emissions monitors (CEMs) for SO_2 on new or modified thermal power plants in the two control zones were implemented.

A Cap and Trade Program is Compatible with the Existing Pollution Levy System

Developing an SO_2 emissions trading program is a systematic process involving a complex array of regulatory, program design, and program management issues. One of the key issues is to blend an emissions trading program with existing traditional regulations, and existing economic instruments. If China is to use emissions trading to reduce SO_2 emissions, the relationship between the trading program and the pollution levy system needs to be addressed. The pollution levy system is among the oldest and most important components of China's regulatory structure for controlling SO_2 emissions. The levy system is also used to help fund the local environmental protection bureaus.

An expert economic analysis from the Massachusetts Institute of Technology was commissioned for this study to examine the interface between an emissions trading system and China's pollution levy system. The analysis concludes that, if carefully constructed, an emissions trading program could be designed to interface smoothly with the existing pollution levy program, with the cap and trade system as the main economic instrument. In the U.S., for example, permit fees on power plants seamlessly coexist with the SO_2 cap and trade program (permit fees are collected to cover the administrative cost of the permit program).

Barriers to Cap and Trade in China

After analyzing the current infrastructure and policies for SO_2 control in China, the study team identified the following issues in need of attention prior to the widespread introduction of SO_2 emissions trading in China.

- *Emissions monitoring, verification and reporting*: An SO_2 emissions trading program requires the accurate and consistent measurement of all emissions. At present, China has in place an emissions declaration (self-reporting mechanism), and a system to verify emissions data on an annual basis. However, a significant gap still exists between current practice and an adequate emissions monitoring and reporting plan that could support a cap and trade program in China.

  Calculating emissions is a fundamental area in need of examination. The vast majority of enterprises in the power sector have not installed automated monitoring devices. The only exception to this rule are ten newly constructed power plants with automated monitoring capabilities, but even among these enterprises monitoring systems are not being effectively operated. Consistent norms for installing and operating monitoring equipment are essential.

The U.S. experience suggests that pollution sources participating in a trading program employ CEMs. Due to the large number of SO_2 emissions sources in China and the cost of installing such equipment, it will be difficult for China to install CEMs for all large sources in the near future. There will likely be a transition phase with regard to emissions measurement where some sources will use mass balance estimation methods while others will use CEMs. The first priority for deploying CEMs should be on facilities that use combustion or post-combustion controls because the sulfur in the fuel is not a good indicator of the SO_2 emitted. The most important aspect of emissions measurement is that the method is as accurate and consistent across sources as possible.

- *The Power Sector*: Though currently undergoing reform, the Chinese power industry is primarily a state owned industry. Currently, sources cannot pass the costs for pollution controls onto consumers. If electricity pricing policies are not adjusted, the electricity industry will lack revenue channels and the flexibility necessary to operate in a market-driven trading environment, making it difficult to adopt effective measures. Presently, China is conducting research on electricity pricing reforms.

- *Economic Reforms*: Cap and trade programs use market forces to reduce overall compliance costs. However, at present China still has largely a planned economy. Additional market reforms that further link enterprise-level decision making to market forces rather than planning mandates may be needed to support the use of emissions trading in China.

- *Legal Support*: China's current air pollution prevention and control law supports the use of TEC, however it does not yet directly support the use of emissions trading. It indirectly suggests using economic and technical measures to control air pollution which implies that it is possible to employ emissions trading. However, there is a lack of explicit legal provisions regarding emissions trading in the new law. Without explicit legal and regulatory authority, it is doubtful that emissions trading can be successfully applied.

Recommendations

In summary, China is developing the necessary infrastructure for application of SO_2 emissions trading, but there is still a considerable amount of work to be done. Infrastructure improvements are needed in the areas identified below. Recommendations are also offered regarding the initial framework for an emissions trading program.

Infrastructure Improvements

The study team recommends the following key infrastructure improvements to support the future use of emissions trading in China.

- <u>Establish clear legal authority to enable emissions trading</u>. A legal basis for emissions trading should be developed by SEPA through "Administrative Regulations." These regulations should then be approved and enacted by the State Council. The regulations should cover criteria for including sources in the trading program, protocols for emissions monitoring and verification, procedures for compliance determination and consistent practices for charging enforcement penalties.

- <u>Strengthen emissions monitoring and reporting practices</u>. Promote the use of CEMs for SO_2 monitoring wherever that is economically feasible and develop more consistent and accurate emissions estimation measurement protocols for sources not using CEMs. The use of CEMs is particularly important where combustion or post-combustion controls are used.

- <u>Establish a consistent and comprehensive emissions verification procedure</u>.

- <u>Establish emissions tracking and allowance tracking systems</u>. The emissions tracking system will help manage the large volume of emissions data collected and will ultimately need to be highly automated with sources using CEMs. Allowance tracking will be critical for verifying "ownership" of allowances and for determining compliance at the end of each year. The tracking system should be designed to enable regulators, stakeholders and the public to have access to the data.

- <u>Continue training programs</u>. Extensive training programs should be developed and used to educate facility operators and program administrators about the theory and practice of emissions trading.

Framework for Implementation

Similar to other new policy initiatives in China, continued experimentation and capacity building at the local level with emissions trading is likely to proceed a large regional program. Once China moves forward in adopting a broad emissions trading program, it should be aimed at combating acid rain in the regions where the problem is most severe, focused initially on major pollution sources, and phased in gradually to cover more area and more sources. With additional legal stature, the current TEC program in the 5 Year planning cycle provides a foundation for setting the SO_2 emissions cap on both a national and regional scale (for the two control zones).

Based on the regional nature of the SO_2 problem and China's current SO_2 policy and management framework, the scope of the tradable permit program should be first implemented in the two control zones with the first stage of the project focusing on large-scale power plants in the two control zones. Power plants are recommended because they contribute over 30 percent of the total SO_2 emissions in China and are projected to continue growing as electricity spreads into more rural areas across the country. Large plants are also more easily monitored and controlled at this time in China. The current five-year planning cycle could be a convenient platform for allowance allocations and program evaluations.

One possible option for the incremental establishment of an SO2 emissions trading program would be to structure program development in four phases, as follows:

- Stage One: during the introductory pilot stage the scope of emissions trading should be limited to large scale power plants (annual SO_2 emissions exceeding 5,000 tons per year) in the "two control zones";

- Stage Two: on the basis of the pilot results, the trading program should be extended to all large power plants in the "two control zones";

- Stage Three: the trading program could then be extended to all large power plants in China; and

- Stage Four: eventually trading can cover other types of large boilers, potentially including industrial sources.

Summary

Although China does not yet have all of the needed institutional capacity in place to support a broad regional emissions trading program, it is feasible to develop that infrastructure and to use emissions trading to achieve SO_2 reductions in China. Infrastructure needs to support a cap and trade program include: accurate, consistent and complete mass-based emissions monitoring as well as consistent and objective enforcement practices. Further development of these fundamental capabilities will greatly enhance China's ability to use economic instruments such as cap and trade. The development of this infrastructure will also improve the efficacy of all of China's current and future air quality management policies.

To build the supporting infrastructure and begin using emissions trading in China will require considerable time, resources and effort. However, once established, such a system will enable better emissions management and overall cost reductions in achieving the desired environmental goal. This will be particularly important as China's economy grows and reliance on electric power increases.

Controlling China's Power Plant Emissions after Utility Restructuring: The Role of Output-Based Emission Controls[1]

Barbara A. Finamore,[2] Paul J. Hibbard,[3] Nancy Seidman,[4] and Tauna Szymanski[5]

China's well-known and serious air pollution problems owe in large part to outdated and inefficient power plants. Electric power consumes more than forty percent of the nation's total coal consumption, which reached approximately 1.2 billion metric tons in 1999, making China the world's largest consumer of coal. About seventy percent of all electricity in China is generated from coal, much of it from small, inefficient and highly polluting plants built hastily over the last two decades to remedy the nation's severe power shortage. Average thermal power plant efficiency in 2000 was 363 grams of coal equivalent per kilowatt-hour—much higher than that of developed countries.[6] Thermal power plants were also responsible in 2000 for over 7 million tons of sulfur dioxide emissions (over one-third of China's total SO_2 emissions), as well as more than 670 million metric tons of carbon dioxide emissions (approximately one-fifth of China's total CO_2 emissions).[7]

China is pursuing a number of initiatives to reduce emissions from fossil-fueled power plants, including plant closures, investment in desulfurization equipment, and emission control requirements. At the same time, recognizing vast inefficiencies inherent in the current centralized electric industry structure, the government has targeted the electric power sector for structural reform. On April 12, 2002, the State Council announced the latest series of utility restructuring measures, which include breaking up China's State Power Corporation into four or five smaller power generating companies and several electricity grid companies.[8] The power companies will compete with each other in terms of price as they try to win contracts from the grid companies. Introducing competition into electricity generation aims in part to increase efficiency to world-class levels by 2010. As part of its utility restructuring efforts, China is also developing incentives for cleaner power sources.

China's goals of reducing power plant emissions and improving power plant efficiency should not be pursued independently, since (1) the details of electric industry restructuring in China will affect the long-term impacts of this industry on public health and environmental quality, and (2) the details of power plant emission control requirements will affect the fairness and economics of competition in electricity generation. Restructuring rules and environmental regulations will determine the order and frequency in which cleaner or dirtier power plants are operated to meet electricity requirements, the types of new power plants that will be built, and the lifespan of older, more polluting plants. Considering environmental principles in restructuring efforts and recognizing the new industry structures in designing emission control policies will help China achieve its energy and environmental objectives.

The concept of the need to link electricity and environmental policy is not new. The strategy is widely recognized in the U.S., and has played a significant role in electric industry restructuring in this country. For example, many state restructuring laws and regulations include specific provisions to (1) continue ratepayer funding for demand-side efficiency programs, (2) provide funding and/or a guaranteed market for existing and new renewable resources, (3) institute emission portfolio requirements[9] for sellers of electricity and/or (4) require that sellers of electricity disclose to existing and potential customers the fuel source and environmental characteristics of their electricity product. In addition, several states are moving

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[6] Zhongguo Gongye Jingji Tongji Nianjian (Statistical Yearbook of China's Industrial Economy), 2001. Beijing: Zhongguo Tongji Chubanshe.
[7] China's total carbon dioxide emissions from fuel combustion only were roughly 3 billion tons in 1999.
[8] "China to Split State Power Corp Into Smaller Power, Grid Companies," Xinhua News Service, April 12, 2002.
[9] Emission portfolio standards require that the average emission rate of the portfolio of generating resources used by retailer suppliers of electricity not exceed prescribed emission standards for a single or multiple pollutants.

towards new forms of environmental regulation that recognize the changing market dynamics of competitive electricity generation and seek to provide a level playing field for cleaner, more efficient power plants.

One promising new approach to integrating electricity and environmental policies is to regulate pollution from power plants by limiting emissions per unit of electrical output; i.e., pounds or kilograms of pollutant per megawatt-hour of electricity production. This "output-based"[10] approach is in contrast to the "input-based" method most often used historically in environmental regulation – limiting emissions per unit of fuel or heat input (e.g., pounds or kilograms of pollutant per million British Thermal Units, or mmBTU).[11] As described below, moving to output-based standards encourages the development of cleaner power, aligns the control of power plant emissions with the financial metric of competitive markets, encourages generation efficiency, and promotes fairness among market competitors. In this article, we provide an overview of output-based emission control requirements, drawing on examples from the United States.[12] We then discuss efforts underway in China to incorporate output-based principles in its power plant emission control programs.

[10] Output-based approaches to emission control requirements also have been referred to as generation performance standards (GPS) or emission performance standards.

[11] Historically, regulations to control emissions from large boilers have applied not just to power plants, but also to commercial and industrial facilities that do not involve the generation of electricity as a product (e.g., steel manufacturing, aluminum smelting, cement manufacturing). For this reason, control programs have been based on the common unit of boiler fuel input. The impetus for the move to output-based programs is the introduction of electricity restructuring in combination with the implementation of control programs focused primarily on utility boilers (such as emission trading and state-based power plant rate-based programs). While the move to output-based programs does not require a solitary focus on utility boilers, the tasks of program design and administration can be significantly reduced in utility-only programs.

[12] In the U.S., output-based concepts have been used by states to set power plant emission standards, allocate emission allowances within cap and trade programs, and design emission rate requirements for sellers of electricity. At the federal level, the U.S. EPA has issued guidance documents on output-based methods to assist states in designing rate-based and allowance allocation programs, and recent legislative proposals for national power plant emission controls propose output-based standards.

Output-Based Emission Control Policies

The factors of power plant operation that are relevant to setting input- and output-based standards are depicted in Figure 1. There are three basic factors that come into play when a power plant is operating over a given time period:

a) the level of *emissions* coming out of the stack due to plant operations (in pounds or kilograms),

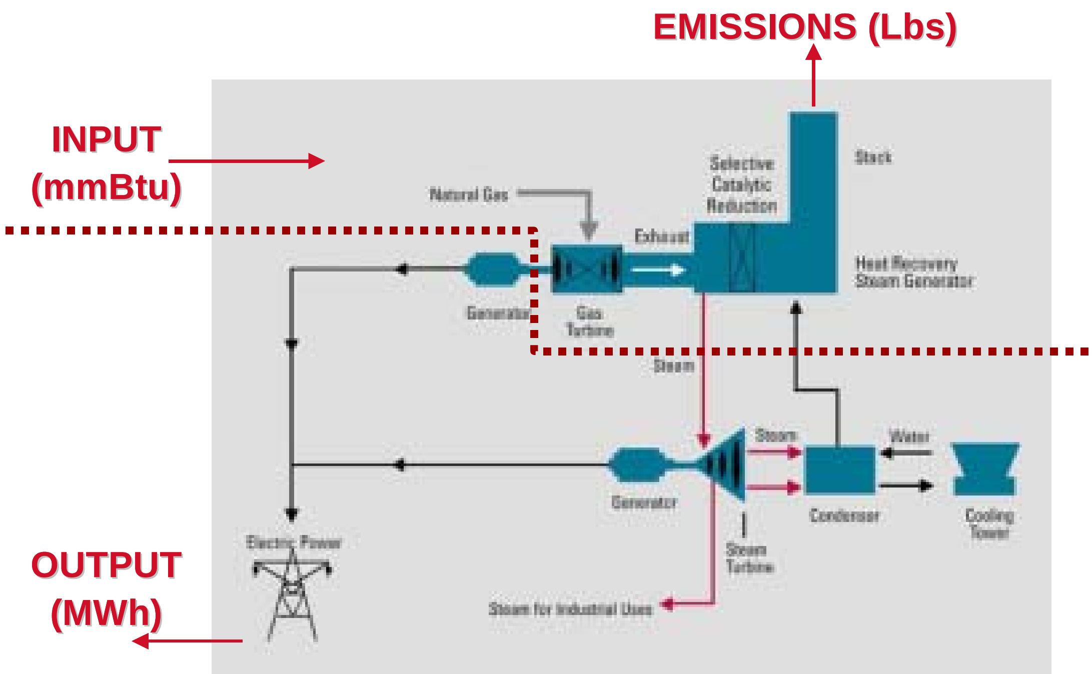
b) the heat content (e.g. in mmBTU) of the fuel *input* to the plant, and

c) the quantity of electrical *output* resulting from plant operations (in cogeneration applications, as depicted in Figure 1, useful steam output also can be included).

Designing emission control programs involves two basic tasks: setting the emission standards, and choosing the mechanism for enforcing the standards. These options are portrayed in Table 1. In order to set input-based standards, the regulatory agency divides the total mass of the pollutant emitted by the facility (measured in tons, pounds or kilograms) over a given time period by the total heat value (in mmBTU) of fuel input to the facility over the same time period. To set output-based standards, the agency divides the emissions by the total amount of useful electrical output (in MWh) generated at the facility over the same time period.

In addition to deciding whether to set emission control standards on an output or input basis, the regulatory agency must choose the mechanism for enforcing the standards. For example, the agency may limit the rate of emissions at individual power plant stacks or for all stacks within a single facility ("rate-based program"). Under a rate-based program, all affected sources must control emissions to ensure that they will not exceed the specified (input- or output-based) standard.

FIGURE 1
Sample Power Plant Configuration



Alternatively, or additionally, the agency may require that facilities participate in a multi-source emission cap and trade program. Under a cap and trade program, facilities may emit any quantity of emissions over a given time period (usually quarterly or annually), but the owner of the facility must obtain and retire an equal number of emission "allowances" (one allowance usually represents one ton of emissions).[13] Setting input- or output-based standards in the cap and trade context involves determining the basis for distributing or "allocating" the allowance budget annually to sources affected by the program.

[13] State and federal governments use a number of air pollution control methods (other than those discussed here) to determine or reduce the level of power plant emissions, including, for example, initial facility siting/permitting reviews, tax and fee programs, exhaust concentration requirements (i.e., concentration per unit of stack gas volume), and fuel composition standards (e.g., maximum percent sulfur concentration in oil or coal). We focus on rate limitations and cap and trade programs because they are used frequently in the power industry and to simplify the discussion.

TABLE 1
Emission Control Program Options

	Input-Based	Output-Based
Emission Rate Limitation (Rate-Based Program)	Rate set as maximum allowable pounds of emissions per million BTU of fuel burned at the facility	Rate set as maximum allowable pounds of emissions per megawatt-hour of useful electrical output at the facility[14]
Cap & Trade Program	Allocation (to states, provinces or affected power plants) based on historical <u>or</u> actual million BTU of fuel burned	Allocation (to states, provinces or affected power plants) based on historical <u>or</u> actual megawatt-hours of electrical output

The Rationale for Moving to Output-Based Programs

Given the mix of generating technologies and fuels affected by emission control programs, and the electricity market structure, input- and output-based programs can provide very different incentives for operators of power plants, and can produce different environmental outcomes. Simply stated, relative to input-based forms of emission control, output-based programs (1) will, at the individual plant level, provide financial incentives to improve generating efficiency, and (2) will, at the electricity market level, provide a price advantage to the most efficient generating facilities. This will in turn lead to an overall improvement – again, relative to input-based programs – in the efficiency of electricity generation in the region.

To illustrate these incentives, Figure 2 poses a hypothetical situation in the context of two power plants that (1) generate the same amount of electricity, (2) are both participating in a regional cap and trade program,[15] (3) are competitors in a regional electricity market, and (4) generate electricity using different fuels and at different levels of generating efficiency.[16] In an output-based program, the initial allocation of allowances is based on electrical output**,** so each facility would receive the same initial allocation.[17] However, the owner of the coal plant would likely be a buyer in the allowance market (since it operates at a higher emission rate and lower efficiency), and the owner of the gas plant a seller (since it operates at a relatively low emission rate and higher efficiency). In this example, the relative economic impact of compliance with the program would represent an economic advantage to the gas plant of over seven hundred thousand dollars per year, which represents over $2 per Megawatt-hour. This economic advantage could influence (1) which type of facility is built to meet growing electricity demand and (2) which type of facility will be dispatched in the daily energy market. To the extent that this relative economic advantage thus translates into a higher level of generation from gas (and lower from coal), or results in efficiency improvements at the coal facility, the program will result in reductions in emissions of all pollutants, as well as reduced water and solid waste impacts.

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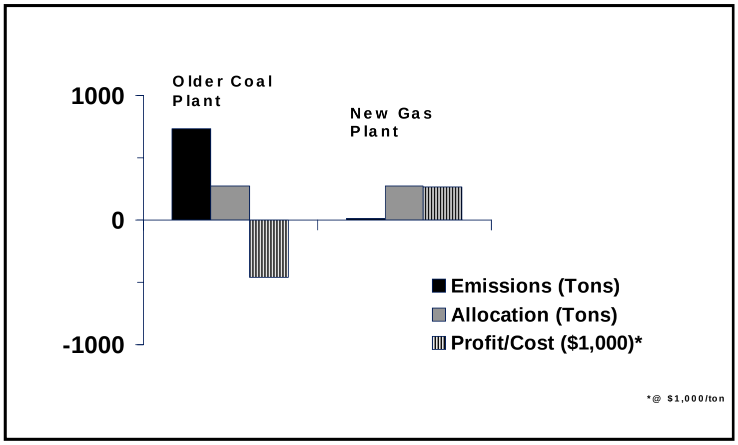
[14] Large point sources that produce useful steam output in addition to useful electrical output (cogenerators), or that produce only useful steam output, can be allocated allowances within a cap and trade program based upon the energy value of their useful steam output.

[15] This example was originally developed in the context of the nitrogen oxides (“NO_x”) 5-month cap and trade program in the eastern United States that was developed in response to the U.S. EPA call for State Implementation Plans (“SIP Call”). Consequently, the example relies on NO_x emission rates and allowance prices roughly representative of that program’s implementation. Specifically, the emission rate assumed for the coal facility is 4 lb/MWh; for the gas facility 0.06 lb/MWh. The market price for allowances is assumed to be $1,000/ton.

[16] Hibbard, Paul J., Nancy Seidman, Barbara Finamore, and David Moskovitz**,** *Output-Based Emission Control Programs – U.S. Experience*, prepared for the China Sustainable Energy Program of the David and Lucile Packard Foundation and the Energy Foundation, May 2000.

[17] Under an *input*-based allocation, the less efficient older coal facility would receive significantly more allowances than the gas facility, since it would require more fuel *input* to generate the same level of electrical output as the gas facility.

FIGURE 2
Output-Based Allocation Example
Economic Impact on Two 100 MW Plants



The example presented in Figure 2 illustrates the potential impact of moving to output-based allocations in the context of a cap and trade program. However, regardless of the type of program or pollutant involved, designing the program on output-based principles should always encourage greater generation efficiency in comparison to input-based program designs. In addition, output-based forms of pollution control appear to be a better fit with emerging competition in the electric industry. In the U.S., economic deregulation of the electric generating sector means that recovery of generating facility capital and operating expenses is no longer guaranteed through regulated utility rates. Cost recovery becomes tied solely to income generated through the sale of useful electricity output. Therefore, for cost recovery purposes it no longer matters whether a facility is run on gas or coal, how much gas or coal was used, when the facility was built, or what pollution control technology was installed. For cost recovery, what matters now is only how many megawatt-hours the facility generates, and the market price for such power. In this new electric industry framework, the principles of fairness and competitive equity suggest that emission control programs should focus on emissions per megawatt-hour, aligning environmental goals with the financial realities of the competitive market for electricity.

Applying Output-Based Emission Control Concepts in China

China recognizes the need to integrate its energy and environmental policies in order to reduce power plant emissions and increase generation efficiency. The State Council's April 2002 electric utility restructuring decree announced that China will adopt new emission standards for power companies and give price incentives to the development of environmentally friendly energy. To this end, China is working to incorporate output-based concepts into the regulation of power plant emissions.

Output-Based Emission Standards

In December 2001, China's State Environmental Protection Administration (SEPA) issued draft revisions to its existing emission standards for thermal power plants. The State Economic and Trade Commission and the State Development and Planning Commission have endorsed these draft standards, which will likely be finalized around the end of 2002. As shown in Table 2, the draft standards incorporate an output-based approach by limiting emissions of sulfur dioxide (SO_2), NO_x, smoke and dust in terms of grams per kilowatt-hour (g/kWh).

TABLE 2
Permitted Air Pollutant Emission Caps Per kWh of Power Generated (g/kWh)

Pollutant		Time Period 1, 2	Time Period 3
Smoke & Dust		2.5	0.7
NO_x		4.0	2.5
SO_2	*In the Two Control Zones*	3.5	1.5
	In Other Areas	5.0	2.5

The standards apply to individual power plants and vary according to the age and location of the plant. In general new, expanded, and retrofitted power plants whose environmental impact reports are approved after the effective date of the standard will have to comply with the more stringent standards listed under Time Period 3, while all other plants will have to comply with the less stringent standards of Time Periods 1 and 2.[18] Over time, the more

[18] In addition, those power plants that were completed between January 1, 1997 and the effective date of the standard, but whose *(footnote continued)*

stringent Time Period 3 standards will gradually be applied to older plants.[19] In addition, plants located within China's acid rain or SO_2 control zones, which cover approximately 11 percent of China's territory, will have to comply with more stringent SO_2 emission control standards than plants located outside the two control zones.[20]

If fully implemented and enforced, these new output-based standards could result in significant reductions of power plant emissions in China.[21] A rough calculation indicates that the standards could reduce SO_2 emissions from new power plants by 57 percent (for plants outside the two control zones) to 74 percent (for plants within the two control zones). Sulfur dioxide emissions from existing plants could be reduced from 14 percent outside the control zones to 40 percent within the control zones.[22]

These output-based standards will not replace the existing concentration standards, which are also being revised.[23] Instead, power plants will have to comply with both sets of standards in order to ensure that each plant will meet a certain level of environmental requirements and to avoid local environmental "hot spots."[24]

Output-Based Allocations under China's Total Emission Control Program

China is also experimenting with using an output-based approach for the implementation of its Total Emission Control (TEC) program. The concept of Total Emission Control – a fixed nationwide tonnage cap on emissions of sulfur dioxide, nitrogen oxides and particulate matter – was first introduced during the Ninth Five-Year Plan (1996-2000).

The Tenth Five-Year Plan (2001-2005) calls for reducing nationwide sulfur dioxide emissions by an

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environmental impact report approval date is over 5 years old and have not passed the examination and acceptance of the responsible environmental departments must also comply with Time Period 3 requirements.

[19] Under the draft standards, thermal power plants that were built or approved before December 31, 1996, must comply with the air pollutant emission limits of Time Period 2 beginning in 2010; thermal power plants built or approved between January 1, 1997 and the effective date of the standards must implement the air pollutant emission limits of Time Period 3 beginning in 2010.

[20] In 1998, China designated two zones in the southern and central regions of the country for the intensive control of acid rain and sulfur dioxide pollution. The Two Control Zones geographically cover only 11 percent of the country but contain sources responsible for 60 percent of sulfur dioxide emissions. The two zones are required to follow technological standards for coal-burning and sulfur-content standards for coal extracted. A pollution levy of 0.2 yuan/kg of SO_2 (200 yuan/ton) was imposed on all sources in the Two Control Zones. Ninety percent of fees collected are supposed to be used to purchase pollution control equipment for the affected sources.

[21] The most stringent of China's proposed requirements – 1.5 g/kWh for SO_2 and 2.5 g/kWh for NO_x – equate to approximately 3.3 lbs/MWh and 5.5 lbs/MWh, respectively. By comparison, recent emission rate requirements issued for power plants within Massachusetts in the U.S. set standards of 3 lbs/MWh for SO_2 and 1.5 lbs/MWh for NO_x.

[22] These rough calculations assume full implementation of the GPS standards, and are based on a 1999 national average SO_2 emission rate of 5.8 grams/kWh (8.1 million metric tons of power plant SO_2 emissions and 1.4 trillion kW of electricity generation). These calculations also assume that 10 percent of China's power plants are located within the two control zones, that baseline emissions from new power plants are 4 g/kWh, and that no other improvements in coal sulfur content or heat rate *(footnote continued)*

would occur outside the GPS mandate. These calculations do not account for the fact that some of the existing stock would be retired before the program was fully implemented.

[23] According to the existing standards, power plants in the two control zones that were built or approved after 1996 must also comply with limits on SO_2 emission concentrations. The SO_2 concentration limits are 2100 mg/m^3 if the fuel sulfur content is below 1 percent, and 1200 mg/m^3 if the fuel sulfur content is above 1 percent. In addition, all thermal power plants must comply with maximum total sulfur dioxide emission limits. These limits are calculated according to a formula that takes into account the age and location of the plant, its stack height (with a maximum allowable stack height of 240m), and meteorological conditions.

[24] It is not unusual for individual power generating facilities to be subject to more than one emission control requirement at any point in time. In the U.S., power plants in most states are subject to more than one control requirement for a given pollutant. This occurs due to the evolutionary nature of scientific knowledge concerning the health and environmental impacts of air pollutants; the existence of separate programs to address different environmental damages associated with emissions of the same pollutant that lead to different but appropriate standards (e.g., separate programs to address acid rain, a long term deposition problem and urban ozone a shorter term public health based problem, both associated with emissions of NO_x); the sequential development of state and federal programs to address these impacts; and the evolution of new monitoring technologies like continuous emission monitors that allow for tighter emission controls and new program designs like emission trading. In practice, the existence of overlapping emission control requirements simply means a power plant's emission control strategy is driven by the most stringent requirement.

additional 10 percent by 2005, from 20 million tons to 18 million tons, although the Two Control Zones must achieve an overall reduction of 20 percent. This will be a difficult goal to achieve, especially in light of a projected increase in power sector coal consumption of 100 million tons during this time period.

SEPA has already allocated the national SO_2 emission cap of 18 million tons to each of China's provinces, based on environmental and economic considerations. It is now up to each province to further allocate its provincial cap on a municipal or sectoral basis in order to ensure the necessary emission reductions. In partnership with SEPA, three provinces – Shandong, Zhejiang and Shanxi – have volunteered to test the use of an output-based approach to allocate their provincial SO_2 emissions cap. Shandong relies almost completely on coal-fired power production and has the highest levels of sulfur dioxide emissions in China. Zhejiang suffers from some of the most serious acid rain in China and is concerned about impacts on its agriculture and tourism industries. Shanxi is the leading coal producing and consuming province in China, with over one million tons of annual sulfur dioxide emissions. Taiyuan, the capital city of Shanxi, is also experimenting with emission trading as a market-based mechanism for SO_2 emission reduction.[25]

When it launched the three provincial pilot projects in November 2001, SEPA noted that output-based emission controls (which the agency refers to as generator performance standards, or GPS) represent the best option for integrating economic development and environment protection in the utility sector. The agency said that GPS can eliminate the adverse impacts arising from highly polluting and inefficient fossil fuel-based power plants, encouraging power generators to build new and cleaner facilities while compelling technological innovation at those existing power plants. SEPA believes the implementation of GPS will push severely polluting enterprises to intensify their environment management or make efforts to reduce their aggregate emissions through energy efficiency or the adjustment of power output mix (e.g., by the use of renewable energy), thus achieving the win-win objective of improving environmental quality and developing a green power economy. SEPA found that an output-based approach is compatible with, and could have far-reaching significance for, China's emerging competitive power market and could put the power industry onto the track of sustainable development.

Conclusion/Next Steps

The existing and expected future expansion of China's electricity system relies heavily upon exploitation of China's vast resources of low-priced coal. While this may appear a low-cost path to economic development, it comes at a heavy price in terms of human health impacts and environmental degradation. China's air quality is already among the worst in the world, and it will be very difficult – or at least very expensive – to fuel economic growth by increasing coal generation without also increasing the impacts of electricity generation on the health and well-being of China's population, the quality of its environment, and the challenge of addressing climate change.

Moving to output-based standards encourages the development of cleaner, more efficient forms of power generation in a form most compatible with competitive markets. SEPA's draft output-based standards and output-based allocations, which are being developed concurrently with China's overall power sector restructuring, demonstrate prudence and foresight. Incorporating output-based concepts now into the energy and environmental policy framework could allow for smoother adoption of additional market-based mechanisms such as renewable portfolio standards. While not a cure-all by any means for the environmental predicament burdening China's economic development, adopting output-based emissions standards can hasten the switch to the use of cleaner fuels, the adoption of more efficient market-based mechanisms, and the internalization of environmental costs into production cost calculations. The standards inherently provide financial incentives to integrate power production efficiency into plant operations and investment.

China's adoption of output-based standards for sulfur dioxide and nitrogen oxides could pave the way for their possible future application to other air pollutants like carbon dioxide. Output-based

[25] In May 2002, SEPA announced that it would be launching a trial emissions trading regime for sulfur dioxide encompassing Shandong, Shanxi, Jiangsu, Henan, Shanghai, Tianjin, and Liuzhou. The first five are provinces, Tianjin is an autonomous city, and Liuzhou is a tourist destination in Guangxi Province with a long history of heavy industry. The announcement emphasizes the benefits of utilizing market mechanisms in complying with total emissions control standards more cheaply, more easily and with greater autonomy. Permit trades will be conducted among firms that are required to comply with sulfur dioxide emissions standards.

concepts are also compatible with emerging mechanisms for combating climate change, such as the Clean Development Mechanism established under the Kyoto Protocol. In the short term, assuming the thermal power plant standards are adopted with little resistance from the State Power Corporation or its spin-off companies, the next step will be to integrate output-based standards with China's existing Total Emission Control and pollution levy systems. That could mean exploring the use of output-based emission allocation with the emission trading system. The emission trading pilot projects that are underway will provide useful experiences for the larger application of these programs.

Health Benefits from Air Pollution Controls in Shanghai[1]

Jia Li[2], David Streets[3], Sarath Guttikunda[4], Gregory Carmichael[4], Young-Soo Chang[3], Virginia Fung[5]

Abstract

Urban development in mega-cities in developing countries has caused significant human health damages through increased consumption of fossil energy and elevated air pollution levels. Averting these health damages by investing in clean energy and industrial technologies and pollution control measures can be expensive. For this study, we examine the city of Shanghai, China, and perform a cost-benefit analysis to illustrate the economic benefits of improved human health from controlling particulate matter (PM10). The study shows that the ratio of health benefits and investment costs is in the range of 1-5 for the power-sector control policy and 2-15 for the industrial-sector initiative. There appears to be considerable net benefits for these strategies, which are largely depending on the valuation of health effects in China today and in the future. This study provides preliminary economic grounds for supporting investments in clean energy and air pollution controls in developing cities like Shanghai.

Background

Outdoor air pollution is taking a toll on the health of people living in mega-cities in the developing world.

Economic development and urban growth are coupled with surges in energy consumption to fuel the increased living standards, the industrial activities and the growing transportation need. As fossil fuels are the primary energy choices and the energy conversion and consumption efficiency is often low, the air pollutant emissions that are generated have inflicted significant health damages on the population, despite the unarguable benefits brought about by the economic boom. In many cities, the pollution levels are often several times the limits recommended by the World Health Organization (WHO, 2000) to protect human health.

The challenge to manage limited economic resources and maintain a sustainable environment is immense. Investments in clean, efficient technologies, pollution prevention and control are often outweighed by the short-term needs to boost economic development and provide job opportunities. Motivated to investigate whether the costs of clean technology investments and pollution controls are too expensive to afford—as developing countries sometimes assert—we have conducted this study in Shanghai, one of the most rapidly growing and prosperous metropolitan areas in China. Our aim is to cast light on the potential economic benefits from improved population health status as air pollution levels decline and to compare these benefits with the expenditures on new technologies and emission control measures needed to achieve them.

As little work has been done to understand the human health impacts of fine PM at urban scale in China, for this study we select particulate matter of diameter less than 10 µm, or PM_{10}, and conduct an integrated analysis of the energy and technology choices, emissions, air quality and the human health effects. Particulate matter of small size is a major pollutant linked with premature deaths, chronic pulmonary diseases and lung function impairments. We establish two illustrative control scenarios and evaluate benefits from improved human health using dose-response relationships established in epidemiological studies in China and internationally.

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Shanghai – Demography and Pollution

Shanghai is one of China's most populous and prosperous metropolitan areas. Situated on the estuary of the Yangtze River facing the East China Sea, the city is home to more than 13 million residents (see Figure 1). The economic boom in Shanghai came with greatly increased demand for energy to fuel its growing economy. Shanghai's energy use has traditionally been dominated by coal, which accounted for about 70% of total energy consumption in the early 1990s. Air and water pollution has historically been severe in Shanghai and associated with adverse health effects. Recently, advancement in the economic condition has also nourished the development of environmental regulation and investments in environmental management and pollution controls. Over the last decade, environmental policies that include relocating heavy industries from the urban centers to less-populated remote areas, replacing residential coal use with natural gas, converting coal-fired industrial boilers to cleaner fuels, and installing end-of-pipe emission controls at large power plants have steadily reduced emissions of air pollutants.

Nevertheless, current particulate levels in Shanghai are high. Moreover, monitoring data in the late 1990s show a geographic redistribution of particulate pollution in Shanghai. In 1999, TSP level in Shanghai's downtown area was reduced by 8% (or 14 $\mu g/m^3$) from the 1998 level, but the suburban TSP level of 152 $\mu g/m^3$ increased slightly from the 1998 level of 147 $\mu g/m^3$ (Shanghai EPB 2000). This reflects a transition in economic activities as more manufacturing businesses move out of the heart of the city. The demography in Shanghai shows a similar pattern—that more residents are migrating from the city to the suburban areas. Focusing only on reductions in urban pollution may mask the risks of increased population exposures to air pollution in the city's outskirts.

Study Methodology

We select 1995 as the base year to establish energy and emissions inventory and project out to the year 2020 to compare the policy options associated with a business-as-usual (BAU) pathway and two alternative scenarios. Fine particles ($PM_{2.5}$) are a better surrogate for the mixture of particulate matter from fuel combustion sources, and they are of greatest health concern because they penetrate deeper into the lung and tend to be more reactive. However, PM_{10} studies are more prevalent because PM_{10} concentrations are much easier to measure in the ambient air. Considering the wealth of epidemiological studies linking PM_{10} with various health outcomes (i.e., mortality, hospital visits, and emergency room visits), we select PM_{10} as the parameter for evaluating the health benefits in the study. If $PM_{2.5}$ were used as the evaluation parameter, the health benefit estimates would be expected to be greater.

This study takes an integrated approach that links emission sources, the ambient distributions, and the human exposures to the particulate matter from various sources in Shanghai. Two scenarios are developed to illustrate the control of emissions from two of the key energy sectors in Shanghai: power generation and industry. The emission inventories, air dispersion modeling, and health impact analysis are developed within a common spatial framework. The species include primary carbonaceous PM, primary mineral PM, as well as the secondary sulfate formed in the atmosphere from SO_2 emissions. Secondary nitrate is not included in this analysis, though we estimate that its contribution in Shanghai is approximately one-half of that of secondary sulfate in the PM_{10} mixture.

Energy use in Shanghai is based on data in the latest version of the RAINS-Asia model (Version 8) (Foell and others 1995, Shah and others 2000). The dataset provides parameters needed to compute energy use by fuel type and by energy-use sector. Emissions are calculated based on the actual or standard emission rates by fuel and combustion technology and allocated to grid cells using appropriate distributions of total and rural population, small industrial facilities, road traffic, and rivers and ocean lanes. The Urban Branching Atmospheric Trajectory Model (UrBAT) is used to calculate the ground-level concentrations of SO_2, PM_{10}, and $PM_{2.5}$. UrBAT is a three-layer Lagrangian puff-transport forward trajectory model (Calori and Carmichael 1999). The area of the Shanghai urban center is about 3,200 km^2 and of the entire Shanghai Municipality about 6,300 km^2. Pollution generated outside the study domain and imported into the domain is calculated using the full ATMOS modeling component for the whole of Asia, as documented in Foell and others (1995) and Shah and others (2000).

Results

Control Scenario for Power Generation (C1) This scenario assumes that all new power generation capacity coming on line in the period 2010-2020 will adopt state-of-the-art integrated gasification combined cycle (IGCC) technology for coal combustion. This amounts to a total generating capacity equivalent to 366 PJ, in addition to planned new capacity of natural gas and oil. In the business-as-usual case, it is assumed that conventional pulverized-coal plants would be built to meet the electricity demand and these plants would install flue-gas desulfurization (FGD) units to control SO_2 emissions as required by regulation. The incremental costs of the C1 Scenario are estimated to be $395 million.

Control Scenario for Industrial Coal Use (C2) This scenario assumes that all industrial coal use is banned in the Shanghai urban area by 2020. It is assumed that 75% of the coal-fired production activities will close down and the remaining 25% will be relocated to neighboring counties. This control scenario is consistent with the urban development policy Shanghai is currently pursuing—namely that heavy-polluting industries are moved away from the densely populated urban area. The total annual cost of replacement is estimated to be $94 million in 2020.

Human Health Implications

A risk assessment method is used to evaluate the human exposure hazards to particulate matter and the health benefits from reduced exposure levels. The health status is measured at various endpoints (e.g., acute mortality, chronic pulmonary disease, hospital visits, and emergency room visits). The benefits of reduced health risks are then translated into economic terms by applying economic valuation methods (e.g., willingness-to-pay, cost-of-illness) and compared with the costs of the alternative emission reduction measures.

In this study we assume a linear relationship of health response to air pollution at each health endpoint. A set of dose-response coefficients derived from epidemiological studies is selected. The analysis mainly chooses epidemiological studies conducted in Chinese cities, complemented with studies in the U.S. and other countries where Chinese studies are not available. Table 1 summarizes the dose-response coefficients used in this analysis.

Epidemiological studies conducted in different countries consistently validate the significant association between PM_{10} pollution and mortality. However, due to differences in study methods, modeling tools, and statistical treatment of data, these studies often do not agree on the magnitude of the effect. For example, in China most epidemiological studies use TSP as the measure and do not find statistical significance between TSP and mortality (Xu and others 1994, 1999). The effect of SO_2 on mortality is often more pronounced. To enhance the robustness of results and limit the effects of statistical errors, the results of a meta-analysis that analyzed the weighted average of PM_{10} coefficient from studies conducted in nine different cities in the world are used (Lvovsky and others 2000). The pooled estimate shows 0.84% change in acute mortality risk in relation to a 10 $\mu g/m^3$ change in PM_{10} level.

For the morbidity endpoints (i.e., hospital visits, emergency room visits, and chronic bronchitis), we use dose-response coefficients based on studies conducted in Chinese cities that used TSP as the measure (Xu and others 1995, Xu and Wang 1993). Chemical analysis of the PM composition of Shanghai's ambient air shows that the PM_{10}/TSP ratio is about 0.6 in the city (Chen and others 2000). We use this ratio to convert the reported dose-response coefficients of TSP to PM_{10}. There is no well-established dose-response relationship linking hospital admissions with air pollution in China. In this analysis, we adopt the results of a meta-analysis of various U.S. studies by Dockery and Pope (1994), which reported a weighted mean of 0.8% increase in hospital admissions with a 10 $\mu g/m^3$ increase in daily mean PM_{10}.

Chronic bronchitis is used as an indicator of air pollution induced chronic respiratory illness. A cross-sectional study conducted in Beijing to explore the association of indoor and outdoor particulate levels with chronic respiratory illness (Xu and Wang 1993) reported that a 100 $\mu g/m^3$ increase in outdoor TSP pollution levels was associated with an increased risk of bronchitis (odds ratio = 1.9, confidence interval = 1.1-3.2). A study by Schwartz (1993) confirmed the magnitude of chronic bronchitis risk for TSP in the U.S.

Table 2 summarizes the estimates of avoided cases of health impairment at each endpoint for the power and industry control scenarios.

Economic Benefits of Improved Health

Although much debate surrounds the economic valuation methodology, we believe the exercise can provide useful information on the relative cost-effectiveness of alternative control strategies. In this analysis, we establish a range of economic values for value of statistical life (VOSL) and three values are used ($60,000, $150,000, and $445,000). The World Bank (1997) has suggested a VOSL of $60,000 in China. We use this number as the lower end of the VOSL estimates. The U.S. Environmental Protection Agency (US EPA 1997) suggests a median value of statistical life of $4.2 million, based on peer review of the valuation literature of wage-premium trade-offs in the job market. By comparing the purchasing power parity (PPP) of the U.S. and China developed by the World Bank (2001), the VOSL is estimated to be $445,000 in China if using a direct conversion. We use this as the higher end of the VOSL estimates.

Though the WTP approach has been widely used in the U.S. for measuring people's attitude toward changes in health risks, transferring the literature from one country to another is not without problems. In 1998, a contingent valuation survey was conducted in Chongqing to reveal people's willingness-to-pay for reducing the risk of death through improving air quality (Wang and others 2001). The study estimated that the range of WTP to save a statistical life was in the range of $16,867 (at 25% probability) to $78,072 (at 75% probability). The median VOSL of the surveyed population was $34,458. Wang and others (2001) concluded that the marginal effect of income on WTP for VOSL is $14,434 for every 100 Yuan of income differential. The estimated VOSL of the Shanghai population is approximately $150,000 after adjusting the Chongqing WTP result with income differential. We use $150,000 as the medium VOSL.

For the acute morbidity endpoints, the opportunity costs of illness (COI) approach is used to reveal the avoided medical care expenses, time spent in hospital visits, and regained productivity from bed confinement and work day losses of family members from taking care of the sick persons. Viscusi and others (1991) measured the trade-off rate for chronic bronchitis risk with the mortality risk of an automobile accident and suggested a median trade-off rate of 0.32. This implies that the potential WTP for reducing a case of chronic bronchitis is $19,200, $48,000, and $142,400 for the three VOSL scenarios.

The total health benefits of controlling emissions from the Power Scenario C1 are estimated to lie in the range of $190-1,162 million (in 1998 price). The health benefits from the Industry Scenario C2 are estimated to be in the range of $121-741 million (in 1998 price). The analysis also shows that the estimates are highly sensitive to the VOSL chosen. When the VOSL derived from the Chongqing WTP study ($150,000) is used, the health benefits of the C1 and C2 scenarios are $417 and $266 million, respectively.

Conclusions

Compared with the costs of the two emission control scenarios, The health benefits estimated in this analysis, however, are conservative (see Table 3). The health benefit/cost ratio of the Power Scenario (C1) is in the range of 1-5 (medium 2.0), and this ratio is in the range of 2-15 (medium 5.4) for the Industry Scenario (C2). The health benefits estimated in this analysis are conservative. First, the study omits the long-term perspective of pollution exposure. Second, this study only addresses the health implications of PM_{10} associated with fossil-fuel combustion. Nevertheless, controlling emissions from power and industrial sources also induces ancillary benefits in reducing emissions of a suite of pollutants (e.g., gaseous SO_2, NO_x, and ozone). Moreover, the estimates of cost-of-illness only reflect the present healthcare system in China. With healthcare reform and the growth of a market economy, it is estimated that healthcare in China will be more expensive in 2020. Another major uncertainty in the benefit/cost ratio lies in the economic value that can be placed on human health damage in China; undoubtedly, as China continues to develop in the future this value will rise dramatically.

The results of the analysis show that controlling air pollution sources in Shanghai induce significant health benefits. Controlling emissions from industrial sources is found to be more cost-effective to protect the human health than controlling power emissions in Shanghai. However, the exposure assessment shows that despite significant reductions in pollutant emissions neither scenario brings the pollution concentrations to safe levels in all segments of the Shanghai metropolitan area.

A World Bank study (2000) concludes that the environmental costs of fuel use in megacities in the developing countries can be so high that the marginal damage costs are comparable, or even exceed the production and retail prices for fossil fuels. Shanghai represents a megacity in the developing world with growing prosperity. It has both opportunities and challenges to tackle its increased energy demand and population growth, urban air pollution, and ensure a sustainable development pathway. The task of protecting the population from health impairments and ecosystem deterioration requires a suite of policy measures across the economy, instead of one or two "winning" policies.

In developing countries like China, it is important to include human health protection as a criterion for urban policy development and form it an integral part of the public policy-making process. In addition to the challenges to manage the ambient air quality in urban areas, the burdens of diseases related to indoor air pollution from burning traditional fuels for cooking and heat in rural areas, such as wood, crop residues, and dung, should not be overlooked. The main groups affected are poor women and children in rural areas and urban slums as they go about their daily activities (Smith 1999). There is an urgent need for enhanced access to clean fuels and renewable energy as the long-term solution to improve the health status and the welfare of the inhabitants who live in the vast areas outside cities in developing countries.

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Table 1. Dose-response coefficients used in the analysis

Health Endpoint	Coefficient	Source
Mortality	0.84	Meta-analysis (Lvovsky and others 2000)
Hospital Visit	0.18	Beijing Study (Xu and others 1995)
Emergency Room Visit	0.1	Beijing Study (Xu and others 1995)
Hospital Admission	0.8	Meta-analysis (Dockery and Pope 1994)
Chronic Bronchitis	0.1	Beijing Study (Xu and Wang 1993)

Table 2. Avoided incidents under the control scenarios

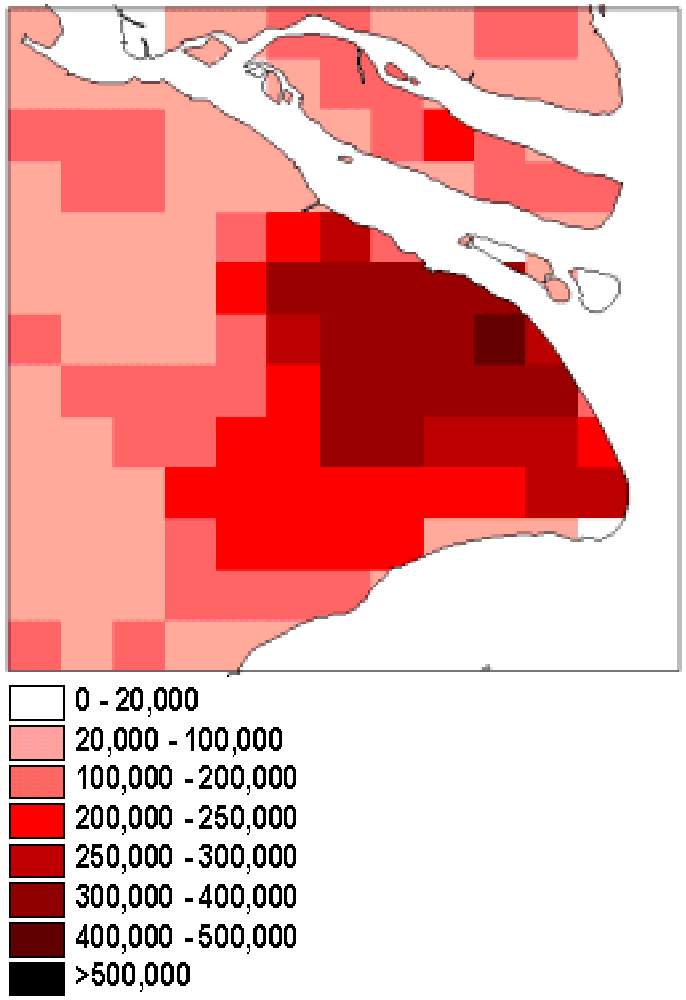
Health Endpoint	Power Scenario C1 (No. of cases)	Industry Scenario C2 (No. of cases)
Mortality	2,808	1,790
Hospital Visit	96,293	61,379
Emergency Room Visit	48,506	30,918
Hospital Admission	43,482	27,716
Chronic Bronchitis	1,753	1,117

Table 3. Health benefit/cost ratios of the control scenarios

Case	Power Scenario C1	Industry Scenario C2
Low	0.9	2.5
Medium	2.0	5.4
High	5.6	15.1

Note: Both the costs and benefits values are inflated to reflect prices in 2020.

Figure 1. Population distribution in Shanghai in 1995



Environmental Briefing

Environmental News Summary from NPC and CPPCC

Compiled by Zhu Weisi

With the development of China's economy and society people would like to care about environment protection much more. During China's "two sessions" (the Fifth Session of the Ninth National People's Congress [NPC] and the Fifth Session of the Ninth National Committee of the Chinese People's Political Consultative Conference [CPPCC]) which were held between March 3rd and March 15th in Beijing, the deputies paid great attention to environment protection as they did last year. Thus we could come to the conclusion that it is the common goal for all of the Chinese to improve ecosystem and protect environment. The following are the Proposals offered by the deputies.

1. Chinese Legislator Warns of Pollution of Water Diverted from Yangtze River

Without intensifying pollution control, the mammoth water diversion project from South to North China would become costly thankless labor, warned NPC deputy Zhang Wentai.

At group discussions of the on-going Fifth Session of the Ninth National People's Congress, Zhang said that water pollution is very serious along the route of the water diversion project and if no effort is made to control the pollution, the water from the Yangtze River would be seriously contaminated and the project would lose its significance.

Zhang Wentai quoted a survey material as saying that the annual wastewater discharge along the planned eastern route totaled 2.951 billion tons and the total discharge of ammonia and nitrogen is 135,000 tons.

The ammonia and nitrogen density has exceeded the prescribed standards at 36 sections and permanganate has exceeded the state set standards in 25 sections. In addition, there are 53 seriously polluted rivers flowing into the water diversion canal.

Although pollution problems have received the attention of all parties, but due to investment and local economic interests, it is difficult to put water control measures in place.

"The key to successful pollution control lies in making laws," he said.

He urged the authorities to set up a special organization to carry out investigation and study and draft laws as soon as possible and put them into execution before the project starts.

2. CPPCC Member Calls for Wetland Law

CPPCC National Committee member Cai Shuming called for the drafting of a law on the protection and control of wetland.

Cai, a research fellow with the Chinese Academy of Sciences, said that China has the law on forestry and the law on marine resources, but it has not had a separate law on wetland protection. Although the Constitution, the criminal law and the civil procedure law have defined the important position of the protection and sustainable utilization of resources, but they have not codified the term "wetland".

He said that the NPC should enact a wetland law as soon as possible to specify the scope of application, ownership of wetland resources, principles and measures for wetland protection, development and utilization and legal responsibilities and related departments should formulate detail rules for implementing the law.

The wetland resources of China total 65.94 million ha. ranking first in Asia and fourth in the world. Since the 1970s, China has demarcated 260 wetland as natural reserves, covering 16 million hectares.

China became a signatory party to the international convention on wetland in 1992.

3. NPC Deputies Pressing Intensified Pollution Control at Three Gorges Dam Project

Deputies to the National People's Congress (NPC) attending the current annual session here have drawn attention to the pressing water pollution problems at the multi-billion Three Gorges dam project.

"If no immediate efforts are made, the water body is sure to deteriorate after the coming second damming of the river for storing water to generate power," said Chen Wanzhi, a deputy director of the municipal environmental protection bureau of Chongqing Municipality in southwest China.

The dam is located at the juncture of Chongqing Municipality and Hubei Province, covering 21 cities and counties totaling 59, 900 sq.km. The area is often hit by landslides and mudflows. Soil erosion is serious. Pollution generated by cities along the Yangtze River, the longest in China, threatens the water quality of the dam area.

According to Chen, investigations by the water resources bureau show that the Three Gorges Area is suffering from such environmental problems as the pollution of drinking water sources by garbage and waste water in large quantity as well as soil erosion caused by resettlement of local residents and towns displaced by the dam project.

The large amount of garbage washed down by floods into the river pollutes the water and will threaten the power-generating facilities, he noted.

According to the Three Gorges Construction Committee under the State Council, the central government plans to invest 43.22 billion yuan in controlling pollution and geological disasters in the area, including 39.22 billion yuan earmarked for improving the quality of water.

Zhang Rongguo, another NPC deputy and deputy director of the designing institute of the Yangtze River Water Conservation Committee, said that in recent years, the government has launched a series of costly programs to curb soil erosion resulting from deforesting. The environmental situation in the area has remained serious in general, though there are some improvements locally, Zhang said.

He urged departments concerned to simplify procedures of approval on environmental projects so as to implement the protective measures as early as possible. "Time and tide wait for no man," he stressed.

4. Experts Called for National Survey of Environmental Situation

Eighteen experts with China's top advisory body have called on the Chinese government to launch the country's first ever nation-wide survey of its ecological and environmental situation.

Eighteen experts with China's top advisory body have called on the Chinese government to launch the country's first ever nation-wide survey of its ecological and environmental situation.

Niu Wenyuan, a research fellow of the Chinese Academy of Sciences and an expert on sustainable development, said lack of understanding of the situation makes it difficult for policy- makers to formulate policies compatible with the real situation.

Citing an example, Niu, also editor of the annual publication "Report on China's Sustainable Development", said three government departments would give three different figures on the area of desertified land in China, making it difficult for scientists to evaluate and compare the changes.

The Chinese economy has been growing at a two-digit rate over the past two decades but few people can tell the actual impact of such rapid economic growth on the country's fragile environment, said Niu, who and other 17 experts on the National Committee of the Chinese People's Political Consultative Conference (CPPCC), China's top advisory body, signed a proposal calling for the survey.

Yang Chaofei, an official with the State Environmental Protection Administration of China (SEPA), said the proposed survey is important and necessary.

Despite recent moves by the Chinese government to protect the environment, ecological degradation has yet to be curbed, said sources with SEPA.

5. NPC Deputy Suggests Law on Recycling Wastes

China needs a law on cyclic use of refuse which is of vital importance to the sustainable development of the national economy, said a lawmaker.

Zhu Tan, a deputy to the Ninth National People's Congress (NPC), China's top legislature, said that at present, China badly needs to establish a circulation system so as to make the best use of resources in the production-consumption-waste-reproduction cycle.

Zhu, a professor with the Nankai University, is here attending the Fifth Session of the Ninth NPC, which opened Tuesday morning in the Great Hall of the People.

Statistics show that more than 150 million tons of garbage are produced in Chinese cities annually, and the amount is rising by nine percent a year. But less than 10 percent of the wastes have been re-utilized, and the total amount of garbage waiting for treatment has exceeded seven billion tons across the country.

Zhu said that urban wastes contain many usable substances which include more than 30 percent waste paper, and a large amount of ferrous and non-ferrous metals, plastics, glass and fabrics.

If one million tons of the waste paper are used in paper making, 600 square kilometers of forest can be saved, Zhu said.

The NPC deputy urged that a special law must formulated to promote the recycling of wastes in China, as it has been done in some developed countries such as Germany, Japan and the United States.

Zhu Zhaoliang, a member of the Ninth National Committee of the Chinese People's Political Consultative Conference (CPPCC), China' s top advisory body, has also put forward suggestions on treatment of refuse.

He proposed that China opens waste treatment as an environmental protection industry to the outside so as to absorb more funds into garbage disposal.

6. Efforts Urged to Eliminate Garbage Yards Surrounding 200 Cities

Garbage has become a scourge for Chinese cities as 200-plus cities now have been surrounded by garbage yards, according to a member of the National Committee of the Chinese Political Consultative Conference (CPPCC), the country's top advisory body.

Zhu Zhaoliang said in a proposal submitted at the annual CPPCC session: "We must try our best to solve this problem."

He said that the amount of urban garbage has been growing substantially in recent years in the wake of faster urbanization and the rapid increase in the urban population.

Statistics show that garbage produced by all Chinese cities amounts to 150 million tons a year, increasing at an average annual rate of nine percent.

The amount of untreated garbage across the country has added up seven billion tons.

Zhu said, "Technically speaking, there is no problem of garbage's harmless treatment. The major problem is insufficient funding input."

According to Zhu, garbage treatment facilities require huge investment costs and operating costs, but government appropriations are very limited.

He proposed that the garbage treatment market should be open to foreign investors, that garbage treatment fees should be slightly higher than treatment costs.

"In this way we can ensure the normal operation of the facilities and take in all kinds of social funds for urban garbage treatment," he said.

Sources: *China Daily* and *People's Daily*

General Environmental News

Complied by Nuyi Tao

1. Legislation and Policy

SETC Offers Incentives to Protect the Environment

The State Economic and Trade Commission (SETC) along with the State Administration of Taxation have announced that they will be offering incentives to Chinese companies for the production and use of environmental protection equipment. To be eligible for the new incentives, the equipment must fall under one of eight categories including, waste water treatment, air pollution, solid waste treatment, noise control, energy saving equipment and utilization of renewable energy.

In theory, companies that buy equipment will be able to deduct the amount of the equipment from their income taxes as an investment. Companies that produce this equipment will benefit from tax exemptions. Perhaps the most significant aspect of these policy trends is a statement that companies using and producing this equipment will be also be given priority in government projects and government procurement funding.

For more information on this and other SETC policies, please visit their website at: http://www.chinacp.com

700 Billion to be invested for improving environment for the next 5 years.

The State council has approved The "Tenth Five Year Plan for State Environment Protection". , The "Plan" set the environmental goal as the alleviation of the environment pollution and the initial curbing of with the deteriorating tendency of biological environment by the year 2005.

A lump sum of RMB 700 billion will be invested to achieve the environmental goal. It accounts for 1.3 percent of the GDP, or 3.6 percent of the gross volume of capital investment in the corresponding period, one percent higher as against that of the "Ninth Five Year Plan" period. Out of the total amount, the investment by government covers RMB 394 billion, accounting for 56 percent of the gross investment while RMB 306 billion will be invested by private sector, a proportion of 44 percent of the gross needs.

Except for the investment from public sector, the Chinese government is determined to promote investment from private sector on waste treatment and pollution prevention. Greater endeavor will be taken to foster market mechanism for sewage and municipal waste treatment.

China North-south Water Plan delayed for ecological and cost concerns

Ecological concerns and high costs are delaying the launch of China's bold project to channel water from its south to the parched north. Xu Kuandi, the new head of Communist Party secretary to China's Academy of Engineering release this news on March 11, 2002 on the sidelines of the annual two-week session of the National People's Congress, China's parliament.

With no outstanding engineering problems, this project's biggest challenges are safeguarding the environment and lowering the north-south water project's estimated RMB180 billion (US$22 billion) cost so northern users could actually afford to buy the shipped water

Environmental experts, both Chinese and foreign, say the leviathan project could spark widespread corruption, human hardship, and environmental damage and could dry up the Yangtze in 30 years. They urge China to take simpler alternative steps like raising water prices, curbing rampant well-digging, stopping leaks, and improving water treatment.

$4.8 billion to be spent on cleaning Three Gorges Water

Government report says Yangtze River is growing more polluted and China plans to spend $4.8 billion to clean Three Gorges water.

The Yangtze River Water Resources Committee issued a remarkably bleak assessment of pollution on the Yangtze River on Tuesday, raising new concerns about the cleanliness of the reservoir that will soon collect behind the massive Three Gorges Dam.

About 23.4 billion tons of sewage and industrial waste were dumped into China's largest river and its branches in 2000, 11 percent more than the year before. Yangtze are now too filthy for any human use, said the report.

China plans to spend nearly $4.8 billion over the next 10 years to reduce water pollution in a reservoir above the Three Gorges Dam. The money would be used to erect more than 260 wastewater treatment plants and some 200 garbage facilities. Facilities would also be set up to collect waste from ships on the Yangtze river, while companies causing serious pollution in its upper reaches would be forced to shut down.

Comprehensive plan set for Yangtze water resources management

A comprehensive program aimed to protect water resources in the entire drainage area of Yangtze River has been reviewed by experts at a state-level meeting on February 24, 2002.

The program is jointly initiated by the Ministry of Water Resources and related departments of 16 provinces, autonomous regions and municipalities in the Yangtze River valley after conducting two years of field investigations.

This program divides the whole valley into four major subareas -- the protection zone, buffer zone, exploitation zone and reserve zone in terms of major functions of local water resources.
The exploitation zone is also further divided into special-purposed subareas where water resources are used respectively for daily life, industry, irrigation, aquatic cultivation, and sightseeing.

This program is the first of its kind that took a holistic approach to protect water resources within the Yangtze River drainage area. Initiated by multiagencies and employing most advanced technologies, this program has great potential to be most effectively implemented.

Based on the current sewage discharge amount of specific areas, the program puts forward limitations over discharge of pollutants tailored to the absorbing capacity in different areas.

If the program is fully implemented, the water pollution in the Yangtze River area is expected to be remarkably reduced by 2010.

2. Environmental findings

Sandstorms tracked down

The most severe sandstorm since 1995 left some 30,000 tons of fine sand and dust in the capital, after hovering Beijing for 51 consecutive hours starting on March 21, 2002.

Chinese scientists say they have pinpointed the origins of the dust storms that have been plaguing China in recent years, as well as the paths the storms follow.

A study sponsored by the State Environmental Protection Administration (SEPA) shows the storms originate mainly in the Gobi and other desert areas in the southeast of Mongolia, the east of Kazakhstan, the east of China's Inner Mongolia Autonomous Region, and deserts in the Xinjiang Uygur Autonomous Region.

In spring and winter they enter China by three different routes, from the north, the northwest and the west, attacking a vast area of inn north China and east China, including Inner Mongolia, Shaanxi, Gansu, Ningxia, Shanxi, Hebei, Beijing, Shandong and Jiangsu.

18 of the 32 dust storms that reached China in 2001 originated from southern Mongolia and the other 14 from Inner Mongolia.

Based on this study, a number of measures have been suggested to stave off dust storms, including improving the vegetation and environment in the areas of origin, establishing shelterbelts in key areas, and long-term cooperation with Mongolia on dust storm prevention.

Dust storms pollute the air, disrupt traffic, harm health and may even cause the death of both human beings and animals. China has had severe dust storms since 1998 and the situation shows no sign of letting up.

3. International business affecting environment

Import tariff on timber product to be lifted

China is expected to give foreign trade enterprises full authority over timber import and export business within the next three years. China has now abolished import quota on logs and timbers, and is planning to cut tariff rates on semi-finished or end-timber products from 15-22 per cent to 2-3 per cent. In 1998, China began a campaign to protect its forests, which reduced log supply to the domestic market by about 60 million cubic metres. Foreign timber products are expected to rush in once China opens its timber market, say experts. The domestic timber business firms will face fierce competition in both price and better offering of quality and variety of timber products.

Horrific computer dumping with U.S. origin found in China

China is becoming one of the dumping sites of the computer wastes shipped from U.S. It was reported that computers still bearing the labels of their one-time owners in America were burned, smashed, and picked apart electronic waste to scavenge for the precious metals inside in a cluster of villages in Guiyu, the southeastern China.

With no organized system to take back and recycle the electronics as Japan and some European countries have, much of the U.S.' electronic waste ends up being passed along a difficult-to-track chain of resellers and parts brokers.

Cheap labor and lack of legislation are the main drivers of the increasing case of computer wastes shipped to China for the salvage of precious metals. Laborers, making $1.50 a day, work with little or no protection, burned plastics and circuit boards or poured acid on electronic parts to extract silver and gold.

The dumping and scavenging process has exposed the worker and their surroundings to innumerable toxic hazards. The ground water in Guiyu is so polluted that drinking water has to be trucked in from a town 18 miles away. One river sample in the area had 190 times the pollution levels allowed under World Health Organization guidelines.

4. Ecofinancing

Forest ecological benefit allowance system started in Fuzhou

On March 12th, Fuzhou City, capital of Fujian Province, formally started the forest ecological benefit allowance system. Near ten million RMB of the national and provincial forest ecological benefit experimental allowance will constantly allocated to the concern 7 counties, cities and prefectures using in key protective forest and special-purpose forest conservation and management. The experimental allowance area is mainly distributed over along main banks of Minjiang River and first- and second-class sources and banks of tributaries and has the allowance of RMB6.422 million.

Foundation established to promote financing of environment protection in Bohai

"Blue Sea", a new foundation was established in Beijing on February 7, 2002, by the China Environmental Protection Foundation (CEPF) and China Charity Federation (CCF). The foundation will invite experts in financing and environmental protection to assess and prioritize its projects. Charity fund grant will be mainly focused on the Bohai, to promote the cleaning of the heavily polluted water.

International cooperation in fight against biopiracy

China, Brazil, India, and nine other of the world's most biodiverse countries signed an alliance on February18, 2002, to fight biopiracy and press for rules protecting their people's rights to genetic resources found on their land.

It has been long criticized by developing countries that wealthy nations are "prospecting" for species in order to patent or sell them without offering concessions or benefits for local people.

Together, the 12 nations in the alliance, which contain 70 percent of the world's biodiversity, said they would press for more equal trade rules on patenting and registering products based on plant and animal resources. One of the grounds the alliance pledged to work on is the U.N. World Summit on Sustainable Development, to be held in Johannesburg, South Africa, in August.

While intellectual property rights and protection for biodiverse areas are at the heart of the alliance, it had no immediate information on what mechanism the group proposes regarding patents and compensation.

Both supporters and detractors of bioprospecting say the 1992 U.N. Convention on Biological Diversity, an international treaty designed to protect host countries and Indian communities, is riddled with loopholes and has been poorly implemented. The United States never ratified the convention.

Sources:
China Daily, People's Daily, Reuters, Environmental News Network, Xinhua Net, Associated Press

Business Development

New Approaches To Emission Control: Development Of A Clean Air, Environmentally Friendly Power Plant In China.

Patrick D. Mulcahy

Case History. China has recently recognized the need to dramatically increase the amount of power available to interior Western provinces, and to become more environmentally friendly in the development of new infrastructure projects on a national basis. The State Power Corporation (Beijing) has issued an edict in 2000 to shut down a large number of older, polluting small power plants. In May 2002, the Bank of China announced they would no longer provide funding to power plants beneath a 130MW standard. The purpose is to shut down those small, highly polluting plants constructed ten to fifteen years ago that burn coal with little if any emission controls. In 2001, the Henan Province Power Bureau was instructed to close nearly 5,000 MW of power generated from these small units, which average 20-to-30 MW each. In addition, the Power Bureau was instructed to initiate new power projects to replace these old units.

Consequently, nearly five years ago, our team in China contacted us regarding the development of a power project near Luoyang City, Henan Province, China. The County of Yiyang and the city officials recognized the need for additional power to that being received from the Henan Electric Power Bureau.

The development company, Team China II- Yiyang Sunshine Power Company, is a Sino-USA joint venture company based in Tustin, California and Luoyang, Henan, China. The company was created to finance, design, build and operate a medium size thermal power plant using the newest technology to reduce fuel emissions and remove pollutants from the wastewater.

The development plan included the diverse strategies required to secure the requisite government approvals, discover the domestic China and foreign equity cash investment, secure Chinese bank debt, select the Chinese Engineering/Procurement/Construction (EPC) contractor, and find the "best available technology" for equipment made in China with USA licensing agreements.

The Project received significant awareness as it was among China's largest clean air, environmentally friendly power plants, and among the first Sino-USA Joint Ventures to achieve State Development & Planning Commission approval. The Project was awarded the Grant from the "International Energy Fund"[6] from the California Energy Commission, and was featured as a model "clean air" project at the "China Energy 2000 Conference" Beijing and Shanghai, the "International Project Finance Conference" 2002, and the "US-China Infrastructure Development Meetings" during the 35th Annual Asian Development Bank Conference, Shanghai 2002.

The Project: The Yiyang Sunshine Power Project is a 110 MW, coal fired power plant using cost-efficient and best available environmentally friendly technologies. These include the new Circulating Fluidized Bed (CFB) technology for the boilers and Electrostatic Precipitator (ESP) for the maximum pollution control. The plant is considered "mine mouth" as it sits on a vast seam of basically waste coal, which is high in sulphur and ash and has low economic value. The area has sufficient water and local limestone for use in the CFB boilers, and is close to grid connecting points. There are two sets of generators, turbines, and boilers with a capacity of 55 MW for each of two power islands (2 X 55 = 110 MW).

The EPC contract is with a major Chinese engineering and construction firm (CMIC/Beijing). Total costs, including equipment, turnkey construction, debt service, insurance, development costs, fees and return on equity investment, is US $83.000.000. The cost per kilowatt is $830, which is lower than domestic and international standards. The tariff to the power bureau is in the mid 30-fen range.

The cost of constructing a "clean air" power plant with fluidized bed fired boilers is approximately 6% higher than with conventional pulverized coal (PC) boilers. Economically, it makes financial sense to construct power smaller power plants that meet and exceed World Bank, ADB and China State Power Corporation emissions standards.[7]

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[1] International Energy Fund, Grant Award Winner, California Energy Commission, May, 2001.

[7] Henan Province Yiyang County Mine Mouth Power Plant Project Feasibility Report; Huabei Power Design Institute, Beijing, China. March, 1998.

Major Issues. The developers approached the Project from the "risk reduction" philosophy and identified the numerous tasks needed for success. It took little time to recognize the many obstacles that lay ahead. The first important contract was the Cooperative Joint Venture Agreement (CJV).[8] This agreement details the responsibilities of both parties in a true Sino-USA Joint Venture. The CJV allows for a 100% tax holiday for the first five years, and 50% reduction for the next five years, as well as other benefits. The Western owners/developers were primarily responsibility for technology solutions and securing the foreign cash equity investment, and working with the Chinese partners to secure the Chinese bank loans (Debt).

Once the CJV was signed, then additional negotiations secured approximately 23 additional agreements and contracts necessary in the Approval Cycle. This cycle took approximately 18 months to complete. The agreements included property rights, water, fuel purchase, fuel delivery, limestone and limestone delivery, antiquities search, environmental agency approval and ash removal and Feasibility Studies.[9] Once these were in place, the County and City petitioned the Henan Province Planning Commission and the Henan Power Bureau for the support to build the Project, which was received.[10]

The initial Feasibility Report and developer's analysis identified the major issues: (1) the size of the project was small, designed to accommodate the limited financial resources of the community (Yiyang County is designated as an "official poverty area"), (2) the coal, which was readily available and in ample supply, was of very poor quality, almost lignite standards, (3) the coal analysis showed a very high level of ash and sulphur, with a low caloric value (3,000 k/cal/kg.), and (4) limitations on the size of the CFB boiler technology. On the positive side, the site was ample, the water and limestone were abundant and ash removal sites available. Most important was the high level of enthusiasm and support from the local and Provincial government officials to make the project a reality.

Political Issues. Faced with these issues, and prompted by a company philosophy that only "environmentally friendly and ecologically sound" projects would be pursued, the developers moved forward. The process fell into two vast areas: one, the political and two, the technical. On the political side, we knew that to achieve the finance objectives for both banks and equity investors, the project would need the security and support of the State Development & Planning Commission (Beijing) and a Power Purchase Contract that would guarantee a certain level of output. In our case, the guarantee was to purchase the full output for a minimum of 4,500 hours per year for a 20-year contract. During this timeframe to secure the government approvals, the technical side began its maturity.

The approval cycle and the technical recommendations went hand-in-glove. It was known the international finance community generally requires State (Federal) approval of major infrastructure projects. However, the small size of the Project (110 MW) presented major problems to secure the State approvals. On one hand the State Power Corporation would only approve coal fired, thermal power plants with a minimum standard of 2 X 300 MW (600 MW). On the other hand, the abundant local fuel was basically useless due to its low caloric value and high level of contaminants. The technical solution came to us from an innovative boiler technology that at that time was new in China, and the world.

Technology Issues. The answer was found in the "Circulating Fluidized Bed"(CFB) boiler technology that eliminated the vast majority of emissions. The problem was that the CFB boilers with a 230-t/h capacity were limited in their size. At that time, the largest boiler capacity available with acceptable guarantees was 55 MW. It was determined at this time to modify the original Feasibility Report to change the plan from a PC (Pulverized Coal) to the CFB boiler configuration of 2 X 55 MW for a total of 110 MW and re-submit the project for local and Provincial approvals. With this done (which took an additional six months), the Project took advantage of a new Procedural declaration from the State Power Corp. called the "Multi-Purpose Utilization Power Plants".[11] This document states that if a Project met the following criteria, it could receive approval, even under the standard size requirements:

[8] Cooperative Joint Venture Agreement, Team China II & Yiyang County, April 3, 1998.

4. Document of Henan Provincial Planning Commission and Power Bureau submitted to SPC on Supplemental Report of Yiyang Power Plant Project (1996 #396)

5 Document of Yiyang Hydrologic Services Bureau on View of Water Supply of Yiyang Joint Venture (1997 #31)

[11] Multi-Purpose Utilization of Power Plants, State Development & Planning Commission, Beijing. 1999.

(1) the plant would be "mine-mouth", and physically located at of the coal strip, and local limestone had to be present,
(2) the limestone and coal could not use the badly congested railroad system for delivery,
(3) coal had to be of low caloric value,
(4) located in a "poverty zone",
(5) use of foreign equity capital and a true Sino-Foreign Cooperative Joint Venture, a
(6) the project must have 90% China equipment content, and,
(7) use of CFB Boilers and other technical issues.

Now, the Project met the approval criteria that allowed smaller, non-pollutant power plants to be constructed. Soon after, the project received the valued approval from the State Planning & Development Commission.[12]

Pollutant Control. The technical analysis showed that the main air pollutions emitted are SO2 and fly ash. The project utilizes two (2) 230t/h CFB boilers with projected sulfur removal efficiency of 85%. The SO2 emissions are ¼ below the Allowable Discharge with NOx Emissions at a very low level (100 ~ 200 ppm). The impact on pollution discharge using the combination of CFB boilers and the addition of the ESP is critical to final performance. Additional pollution control comes from the Electrostatic Precipitator (ESP) with collecting efficiency of 99.7%. The ESP units remove solid particulate from the CFB flue gas stream. After passing through the ESP, the dust content in the flue gas will surpass all environmental requirements and will be emitted to the atmosphere through the chimney.[13]

Coal Analysis. The project has the advantage of an abundance of local coal at absolute lowest costs. The cost per ton delivered is less than US 0.09 cents per metric ton. The disadvantage is the low quality of the fuel. The design coal is bituminous coal of low quality with approximately 51.27% ash content, volatile matter of 33.03 and a 1.17% to 2.4% sulfur (Sar) content. The low order heat rate Qar net is 14.542 MJ/kg. The BTU rate is nearly 11,000.

The daily consumption of coal is 1,000 t/day with a daily limestone consumption of 176 t/day. The limestone (basically CaO) is used as the sulfur sorbent and is a critical element used in the CFB boilers to reduce emissions.[14]

Allowable Air Pollutants Emission Quantity. At the capacity of 2 X 55 MW, the allowable SO2 "Emission Quantity" is "4.6 t/h"; the Project Design is "0.2734, which is 5.9% of the allowable. The actual emission quantity of SO2 is far lower than allowable. The Allowable "Emission Concentration" (mg/Nm3) is 1200. The Design is 461.3, which is 38.4% of Allowable. The Allowable " Fly Ash Emission" is 500. The Design is 175, which is 35% of Allowable. It is apparent that the technology (CFB with ESP) more than accomplishes the goal of a non-pollutant power plant and that Emission Control is significantly enhanced using this system.[15]

There is no ash water discharged from the ash disposal yard as a result of using dry ash handling system. The use of a 150-meter high chimney enhances pollution control. The ground concentration of SO2 and fly dust caused by the plant is reduced with a tall chimney.[16]

Flue Gas Mitigation. Adapting the ESP with four fields has a design collection efficiency of 99.7%. A Continuous Emission Monitoring System (CEMS) will automatically monitor the levels for SO2, NOx and CO2 and the temperature and water content in the flue gas. A signal is sent to the Distributed Control System (DCS) in the central control room in order to control fuel burning in the boiler and pollutants emission concentration.

Water Pollution Precautions and Wastewater Discharge. The various wastewater and sewage flows from the power plant are discharged after treatment. The Industrial wastewater disposal system is complex and is designed to not only save as much water as possible for re-use, but to treat all

7. State Planning Commission Ji Jiao Neng (1997) 2371
8. Technical Analysis to the EPC contract, CMEC International Engineering, Beijing. May, 2001.
9. Technical Analysis to the EPC contract, CMEC International Engineering, Beijing. May, 2001.
10. Document of Henan Provincial Environmental Protection Bureau on View of Settlement of Yiyang Power Plant Project (1996 #45)
11. Emission Standard of air Pollutants for Thermal Power Plants (GB 133223-1996)
12. · Integrated Wastewater Discharge Standard (GB8978-1996) Grade 1.

water to carefully avoid spillage into any landfill or streams.[17]

- The blowdown water from the cooling towers will be reused for sprinkling and washing of the plant coal handing system and dust suppression.
- The washing water of the coal conveyer belt and the water collected from rainfall in the coal yard will be treated through the coal-water treatment equipment.
- The oil-contaminated wastewater will be treated with two sets of oil-water separators from the main power building and the fuel oil storage area.
- The Domestic Sewage and rainfall water system is segregated with a two-phase biological treatment: one underground sewage flow gathered into the sump pit of the sewage pump house after treatment by the septic tank.

Environmental pollution is not reserved to fuel emissions and wastewater, but also to "noise" and the "view shed", which is the direct visual impact on the site and the community at large. The landscape of the power plant is designed for use by the local community as a park. Reclaimed water forms a pond for wild foul.

Noise Mitigation. Noise level limits of the equipment will be provided and exceed standards. The noise level for the main equipment does not exceed 90dB(A). A high efficiency silence standard is used in the main boiler area so that the noise level of exhaust steam is decreased to less than 110dB(A). Double door and hermetic windows in the Control Room with sound damping roof and wall reduces the noise level to less than 60 dB (A).

Environmental Management Team. The environmental protection works are organized and supervised by the Environment Manager. An environmental monitoring station will be in place with three technicians, each one of which represents a discipline: environmental engineering, analytical chemistry and thermodynamics. They, working as a team, oversee the information about meeting standards for various pollutant discharge outlets and operating status for environmental analysis, and prepare the reports on a regular basis.

Conclusions. The developers have found that the Project can provide up to 130 MW of power generation at unity factor or 110 MW at a power factor of 0.8 using waste coal and local limestone without material negative impact on the environment. Use of the "CFB" boiler technology has a desulfurization efficiency of more than 85%. Use of Electrostatic Precipitators (ESP) has a 99.7% efficiency of particulate removal. SO_2 Emissions are 1/4th below allowable discharge. The "footprint" on the local community is positive. The Project brings important financial value to an otherwise useless fuel source. The generation of power will positively impact electricity availability to local factories to increase labor hours. The Project as a "model environmentally friendly power plant" can be replicated in other Western provinces of China with similar seams of low calorie value coal and ample limestone. The Project is a cost-effective, non-polluting footprint for energy generation.

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Field Notes

Report on the United Nations Sustainable Development Forum on New and Emerging Technologies

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Background

The United Nations Forum on "New and Emerging Technologies and Sustainable Development" was sponsored by the UN Department of Economic and Social Affairs and hosted by the Chinese Ministry of Science and Technology. The Forum was held in Beijing, April 15-17, 2002. It was participated by around 250 high-ranking delegates and representatives from 54 countries around the world. The purpose of the Forum is to enhance exchanges and cooperation between business-science partnerships in utilizing new and emerging technology for sustainable development. The two essential missions are: (1) bring together leaders from academia, the scientific community, professional institutions, business and government to harnessing the potential of new and emerging technologies for promoting technological cooperation and local capacity building through international partnerships, and (2) find a way for developing countries to either acquire or develop, and apply new and emerging technologies. As one of the keynote speakers, my presentation topic is "Sustainable Development: Environmental Strategy and Technology." (For those who want a copy of my presentation, please contact the author at cs.tt.shen@worldnet.att.net).

The action plan and programs of sustainable development as spelled out in Agenda 21 was issued after the 1972 United Nations Conference on Human held in Stockholm. The Agenda 21 consists of 40 chapters and hundreds of pages. It requires the application of science and environmentally sound technologies to eliminating poverty and sustaining economic development, advancing social priorities, and protecting the environment. Most delegates felt that the current gap between "developed countries and developing countries" in the generation of new and emerging technologies and their application to practical problems constitutes a "technological divide" that must be bridged if developing countries are to participate effectively in achieving the goals of sustainable development.

As of today, the progresses of sustainable development have been considered inadequate; the challenge is to find new and innovative ways of ensuring a more effective cooperation and transfer of technology and knowledge and also building and strengthening of science and technology capacities in developing countries. The new and emerging technologies have the potential to play an important role in achieving sustainable development goals. In order for developing countries to meet their sustainable development goals, they must have access to environmentally sound technologies, which require technology transfer, technical cooperation, and building science and technology capacity to participate in the development and adaptation of these technologies to local conditions.

The world is getting smaller and the people closer as our transportation and communication technologies advance. We are moving towards a single global conversation and a single global environment. This trend has profound implications for developing countries that face an important role with challenges in confronting environmental issues. Industry is the engine of economic growth, but this engine of growth is highly polluting in many developing countries. Pollution management technologies are available such as pollution prevention, clean production, design for the environment, eco-design, environment management system, life-cycle assessment, total cost analysis and others in most developed countries, but not in developing countries.

Today's global economy has reinforced the geographic separation among resource extraction, production, and consumption. Unfortunately, those who reap the economic benefits of using natural resources often do not bear the environmental pollution costs. To ensure harmony between mankind and nature and alleviate the pressure on resources and the environment exerted by social and economic development, all nations need to recognize science and technology as an alternative of major strategic importance to solve their problems. Global business can play a key role in providing investment to achieve sustainable development. The Forum suggested encouraging establishing business-science partnerships that can be implemented for sustainable development.

The economic development, social growth, and environmental protection are three pillars that provide the base for understanding the achieving the goals of sustainable development. These goals require the concerted and conscious effort of all sectors of the society, including the public, business, academia, interest groups and civil society. Many of the pathways to a sustainable future have yet to be developed. Science and technology are being relied upon to provide these developments. For this reason, the Forum on new and emerging technologies provides the participants with an important opportunity in the exploration and recommendation of these pathways.

Generally, the developing countries do not have access to the most effective and economical technologies and know-how to achieve sustainable development in many critical areas. With the ownership of most of the technologies in corporate hands, partnerships between scientific and technological institutions in developing countries and international corporations offer an important way for developing countries to participate in the development and acquisition of those technologies needed for achieving sustainable development. However, in order for this to happen, certain conditions are essential to attract international corporations. One set of conditions concerns political stability, fiscal regulations, currency convertibility, and business laws as they pertain to foreign-owned enterprises. Another set of conditions concerns the scientific and technological capacity of the host country in terms of its human resources, infrastructure equipment, and institutions.

Today, a number of developing countries have satisfied these conditions and working partnerships have been established between international corporations and local scientific and technological institutions. Other developing nations need support in some of these areas to achieve the desired capacity. In some cases, companies may find such support to be well worth the investment. In some cases, companies may not be as clear. In these cases, corporations would do well to consider the potential long-term benefits of bringing a society into the economic mainstream where there is increased interest in its products.

Governments in developing countries have an important role to play in attracting investment and providing an enabling environment for business-science partnerships. Moreover, good policies for providing education and training opportunities are essential to the development of the needed science and technology capacities. Governments are responsible to ensuring the benefits of new technologies, especially information and communication technologies, are available to all, and to developing strong partnerships with the private sector and civil society organizations in pursuit of development and poverty eradication.

Major Areas of Discussion

Due to the time limitation, the discussions only focused on: (1) new and emerging technologies, (2) international business community and capacity building, and (3) international business community and capacity building. Emphasis was given to energy, transportation, agriculture, food, as well as national capacity building and international technology transfer.

1. New and emerging technologies

- What new technologies are needed for sustainable development?
- What modifications are needed to better adapt existing technologies to local conditions in developing countries?

2. Building local scientific and technological capacity

- What local skills and infrastructure are needed for the development of such technologies?
- What mechanisms can harness the potential of the private sector to assist in the development of this capacity?
- How might partnerships be forged for research and development projects that focus on seeking technological solutions to the problems of developing countries?

3. International Business Community and Capacity Building

- What local scientific and technological capacity is needed to attract industries to developing countries?
- How could international partnerships be used to promote new approaches to technology enterprises?
- What role could the international business community play in helping developing countries participate in global scientific and technological development?

Energy Technologies and Transportation Technologies

Based on the United Nations Agenda 21 of 1992, which refers to the environmental problems produced by the energy and transportation sectors and identifies renewable energy as essential to sustainable development. All agreed that energy, the driving force for development, can be generated by variety of sources, which are equally important for meeting the challenges of sustainable development in developing and industrialized countries. Solar photovoltaic, solar thermal, wind, small-scale hydro, advanced biomass, geothermal, tidal, and ocean thermal and wave energy technologies have great potential for developing countries. The reason is that such renewable energy sources can provide stand-alone energy services in the vast areas in developing countries that remain remote from the power grid. With new innovations in renewable energy technology occurring regularly, these emerging technologies offer opportunities and challenges for development and application in developing countries.

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New energy efficiency technologies and energy-efficient equipment will play an increasingly important role in avoiding unnecessary resource consumption and undesirable emissions in the industrial, commercial, residential, transport and power sectors. In addition, there are recent advances in clean coal technology and natural gas turbine technology that promise to reduce emissions and improve efficiency. Fuel cell technology also offers promise as an emerging technology for sustainable development. Fuel cells can be used for stationary power as well as for transportation systems.

Transportation sector is the fastest growing consumer of energy, requires special attention with regard to sustainable development. There are important new advances in fuel cell based vehicles, electric vehicles and hybrid vehicles. Other technological improvements include alternative fuels, fuel additives that reduce emissions and fuel emission converters. The alternative fuels include compressed natural gas, liquefied petroleum gas, alcohol-based fuels produced from various organic and inorganic feedstocks, and synthetic fuels for heavy-duty engines, as well as mixtures of these. Magnetic levitation is one of the few wholly new transport technologies being developed. The questions that rose are:

What new advances will the new technologies be able to offer in helping meet the goals of sustainable development?

What level of scientific and technological capacity and what type of education and training are required to participate in the development of new and emerging technologies?

Are there economic advantages for a company working in the energy and transportation technologies to undertake research and development, and product manufacture in developing countries, and what are the technologies?

Agriculture Technology and Food Security

It was reported that the international community has been particularly successful in fostering improvements in agriculture and food security over the past few decades. Nevertheless, further increases in productivity and the expansion of the crops and cultivars used for food are still needed, especially for the developing countries. New advances in genetics, especially through biotechnology and animal and plant cell engineering, promise to provide these improvements, like the research effort promoted by the Consultative Group on International Agricultural Research that was essential for the “green revolution”. There are already biotechnological initiatives that have been launched in developing countries to improve productivity and protect crops from pests and drought. Since agriculture is a local activity, new crops and cultivars need to be compatible with local growing conditions.

Food production is another area where a marriage between traditional practices and modern technologies can yield great improvements. Such agricultural practices as agro-forestry, no-till cultivation and biological pest control are particularly important agricultural techniques for sustainable development. Most of these are based on traditional practices, which provide a wealth of techniques to draw upon for advancing sustainable development.

Electronic instrumentation, information systems and telecommunications are beginning to have their impact on agricultural production. New sensors and wireless telecommunication technologies provide affordable systems for improving agricultural productivity. Farmers in India are now using wireless communications systems to obtain market data so they can better select crops and time their harvest when market prices are expected to be higher. Using geographical information systems in combination with climatic data, many countries are now able to optimize the use of land for agricultural production based on local climatic, soil and water conditions.

National Capacity Building

The discussion of national capacity building got a lot of attention. International enterprises considering investment in new and emerging technologies in developing countries are attracted most to those countries with scientific and technological capacity. This includes appropriately educated and experienced human resources, infrastructure and equipment, manufacturing capability and management.

In fact, a significant proportion of scientists and engineers, who were born and received their early education in developing countries, are now working in key academic and research institutions as well as cutting-edge industries in the USA and Europe. This demonstrates the existence of the required human resource potential in developing countries. What are often inadequate and in need of strengthening are the local research and development environment, the infrastructure and the technology, and the security and the incentives.

International Technology Transfer

Developing countries require new technologies adapted to their local needs and conditions and supportive of the goals of sustainable development. The reality is that the ownership of most technologies lies in the private sector. Technology transfer is the best way for developing countries to acquire these technologies, and cooperation with the private sector is an effective way of acquiring them. In addition to enabling developing countries to better meet their development goals in a sustainable fashion, business-science partnerships need to ensure that the developing countries also have knowledge; skills and resources that can prepare them to participate in the global economy.

Some international corporations have already learned that investment in capacity building through partnerships can eventually enhance their own profits. A number of developing countries are now running research and development facilities in such fields as, biotechnology, plant genetics, pharmaceuticals, information technology, electronics, renewable energy, clean production and pollution prevention technologies. The potential of these facilities and their acquired and developed technologies can be harnessed for developing technological solutions of sustainable development for local application.

General Comments

Science and technology have had a profound impact on human development. In this age of globalization, rapid advances are being made in various fields such as: information, telecommunications, pollution prevention and clean technologies, transportation technologies, energy, health, materials, and biotechnology, electronics and nanotechnology.
These new scientific and technological advances are imposing a new social and ethical responsibility on the scientific and technological community to direct their application of these new developments in ways that strengthen efforts for achieving the goals of sustainable development.

Governments of developed countries are responsible to ensuring the benefits of new technologies, especially information and communication technologies, are available to all, and to developing strong partnerships with the private sector and civil society organizations in pursuit of development and poverty eradication. Governments have an important role to play in attracting investment and providing an enabling environment for these partnerships. Moreover, good policies for providing education and training opportunities are essential to the development of the needed science and technology capacities.

In an effort to identify more effective ways of ensuring technology cooperation and transfer as well as science and technology capacity, the Forum focused on partnerships between the science and technology and international business communities. Such partnerships can be an effective way of providing science and technology inputs required by industries, transferring technologies, strengthening science and technology capacities and eventually expanding markets in developing countries. Where science and technology human, institutional, infrastructural and/or managerial capacities need strengthening, both government and private corporation should consider supporting the strengthening of these capacities as a long-term investment for both local science and technology resources and markets. The international business community has a responsibility to direct more of its activities toward achieving the goals of sustainable development, especially to reducing material and energy inputs, and waste emissions, and to contributing to improving the economic and social conditions in developing countries through poverty reduction and providing opportunities for entry into the global economy.

Conference Corner

International Wind Power Conference Held In Paris: Wind Energy $78 Billion Business & 10% Of Electricity By 2020

The first Global Wind power Business Conference was held April 2002 in Paris. The wind energy market could reach 60,000 MW worldwide over the next five years, more than doubling its present output. "Wind energy today is the fastest-growing power technology," said conference chairman Rakesh Bakshi, adding that, "the world has taken about 25 years to reach 25,000 MW, but over the next five years, we expect to reach 60,000 MW." European Wind Energy Association (EWEA) President Arthouros Zervos said that a projection by the association and Greenpeace showed that 10 percent of world's electricity could come from the wind by 2020. This would ramp up to a world investment of US$78 billion in that year. The conference was held in the CNIT, La Defense, in Paris and was hosted by the European Wind Energy Association (EWEA), the American Wind Energy Association (AWEA), and the Indian Wind Turbine Manufacturers' Association (IWTMA). In all, 1,600 delegates and exhibitors from 50 countries attended.

Christian Pierret, French Minister of Industry and finance, said that 10,000 MW of new wind energy capacity would be needed in France by 2010 to meet European clean energy commitments. Christian Pierret said that, "to get there we have introduced an obligation on electricity suppliers and a fixed price for wind energy output. This will create a rapid and strong development." India's Minister for Non-Conventional Energy Sources, M. Kannappan, said that his government has plans for an additional 6,000 MW wind power by 2012. He said that wind would also help bring power to some of the 76 million households that currently have no access to electricity. Brian Wilson, U.K. Minister for Energy, said that Britain had taken its "biggest step ever toward the creation of a significant renewables sector by setting into effect the 'Renewables Obligation'." This aims for 10 percent of electricity from renewable sources by 2010 in the U.K.. A part of that goal will be met by the 1,500 MW offshore capacity already approved. South Australian Member of Parliament Bob Such said that Australia is about to see a large number of projects start generating because of the national mandate for 2 percent of electricity to come from renewables. He expected a 1,100 MW target for wind energy to be easily exceeded. Celebrating his county's leading position in the world wind energy market, German M.P. Hermann Scheer projected 25,000 MW to be installed in Germany alone by 2010, not including a long list of proposed offshore wind energy generation projects. "The German success is based on a mixture of political support and a guaranteed price," he said. Jamie Chapman of AWEA, commenting on the phenomenal 66 percent growth in U.S. capacity in 2001. "The U.S. Congress is set to soon debate a national goal of 10 percent renewables in the energy mix by 2020." See the full story at SolarAccess.com website http://www.solaraccess.com/news/story?storyid=1797. Also visit the American Wind Energy Association website at http://www.awea.org/ .

Next Issue and Call for Papers

The next issue of Sinosphere will focus on energy efficiency issues in China's residential and commercial buildings, a sector that has seen tremendous physical expansion in the last two decades and is likely to continue to boom for the next twenty years. More than one-half of China's urban residential and commercial building stock in 2015 is expected to be constructed after the year 2000. Demand for energy services in new buildings will be greater than ever. How efficiently energy is consumed in and by these buildings has great implications for the local and global environment. Despite increased efforts China has not yet achieved substantial results in energy conservation in buildings, especially in the area of improving the energy efficiency of space conditioning (cooling and heating). Residential buildings in China are estimated to consume 50–100% more energy for space heating as compared to buildings in similar cold climates in Western Europe or North America, and still provide far less comfort. A critical aspect of China's building energy waste problem is that the use of highly energy inefficient designs, materials and construction practices has been continuing almost unabated through the construction boom since 1990. Energy efficiency standards are either lacking or not well enforced. Central heating systems are still based on designs from the 1950s which allow no consumer adjustment of heat levels, while heat pricing and billing policies are deprived of any incentives for conservation and efficiency improvement. Just to give a few examples.

Energy efficiency in buildings is a rather comprehensive subject and is affected by many factors. We are particularly interested in investigations, analyses, or discussions of policies and instruments (market or regulatory) that promote behavioral changes and investments in more efficient appliances, more efficient building designs and construction practices, in China and abroad. Interested parties may send his/her article to Feng Liu at fliu@worldbank.org for consideration.

Thank you for your attention.

Feng Liu
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