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Table of Contents

TABLE OF CONTENTS **1**

SPOTLIGHT ON CHINA **3**

CHINA'S ENERGY CONSERVATION CHALLENGE: ENERGY CONSERVATION AND RENEWABLE ENERGY
By Sandra Cornell *3*

FEATURED ESSAY - CHINA'S ENVIRONMENTAL REGULATORY SYSTEM

SHAPING AN ENVIRONMENTAL PROTECTION REGIME FOR THE NEW CENTURY: CHINA'S ENVIRONMENTAL LEGAL FRAMEWORK,
BY ZHANG HONGJUN AND RICHARD FERRIS, JR. 5

FEATURED ESSAYS – CHINA'S ENERGY EFFICIENCY INDUSTRY

ENERGY CONSERVATION WITH CHINESE CHARACTERISTICS: AN UPDATE ON PROJECTS TO EMPOWER THE MARKET
By Jeffrey Logan *9*

ENERGY DEVELOPMENT AND ENVIRONMENTAL CONSTRAINTS IN CHINA
By Lin Gan *13*

RATIONAL AND CLEAN COAL USE IN CHINA
By Lanqing Jia *21*

CHINA ENVIRONMENT BRIEFING

By Changhua Wu *26*

CHALLENGES TO ENVIRONMENTAL EDUCATION IN THE 21ST CENTURY

By Thomas T. Shen *30*

FIELD NOTES – ABSTRACTS FROM RECENT RESEARCH

ENERGY EFFICIENCY AND CLIMATE IMPACTS OF FOREIGN DIRECT INVESTMENT IN CHINA'S POWER SECTOR
By Allen Blackman and Xun Wu *35*

PACE WORKSHOPS: RECENT AND UPCOMING

BROWN BAG SEMINAR ON DEVELOPMENT OF CHINA'S ENVIRONMENTAL LEGISLATION 36
TSINGHUA UNIVERSITY TO BECOME THE FIRST GREEN UNIVERSITY IN CHINA 37
CREATING INCENTIVES FOR INDUSTRIAL FIRMS TO CONTROL POLLUTION IN CHINA 37

CONFERENCE CORNER 38

CALL FOR CONTRIBUTIONS 38

Editorial Board

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Spotlight on China

China's Energy Conservation Challenge: Energy Conservation and Renewable Energy

By Sandra Cornell

A generation ago China's major cities were plagued by drastic electricity shortages. A nationwide industrial revolution was underway. Industry surged with vigorous output but inefficient technology greedily chewed up more power than the inadequate electricity network could supply. Blackouts struck frequently and unpredictably - a quarter of a city, millions of residents, unexpectedly plunged into cold, mid-winter darkness at times of peak demand.

That was then. Today, the country's major cities are able to maintain continuous electricity supply. But the challenge of meeting the ever-growing demand for power has not gone away. As recently as last summer, here in Shanghai, one of the country's most technologically advanced cities, electrical supply capacity was "maxed out" due to record high temperatures and record high user demand. Peak power load on the Shanghai grid exceeded the city's generating capacity by nearly two million kilowatts. The shortfall was made up by redirecting power from neighboring provinces, but not without the word "blackout" once again being uttered as a possibility.

According to official statistics, 75 percent of the country's energy is produced from coal. (compared with 27 percent in developed countries) and with electricity demand estimated to quadruple by 2020, China is poised to soon overtake the United States as the world's leading producer of greenhouses gases.

China has long been aware of both the economic and environmental implications of the country's swelling electricity requirements. Since the early eighties authorities have been encouraging the conservation of energy and, more recently, promoting the use of alternative energy sources.

Technological advances in industrial equipment have greatly improved China's energy efficiency since the mid-seventies when China's production sector was among the most technically and economically inefficient in the world. The growing demand for better production methods and better quality goods means ongoing improvements in industrial technology, and consequently, ongoing improvements in energy efficiency.

Government efforts to promote energy conservation have also had a positive impact. Researchers at the Lawrence Berkley National Laboratory in Berkley, California have determined that direct energy savings from state-sponsored conservation projects accounted for between 11 percent and 15 percent of the energy efficiency improvement in China between 1980 and 1990.

Current changes in the economic structure of the country, however, mean that state influence over industry is lessening. Previously successful strategies for promoting energy conservation, such as energy quota management, efficiency standards and energy awareness training, may no longer be appropriate for a modern, market-oriented industrial sector.

China's new "Energy Conservation Law", which was introduced on 1 January 1998, aims at addressing this reality. The new law is intended to guide and stimulate energy conservation activities throughout society, and to improve energy efficiency despite weaker government control of enterprises.

Here in Shanghai, authorities are developing local regulations to enforce energy efficiency improvements in the city's industries. The draft regulations emphasize the use of new technologies, and requires local governments to provide energy-saving technology services and both energy producers and end-users to computerize the management of energy consumption. The city consumed 39 million tons of coal last year, up 2.2 percent from 1996, and discharged 524.9 billion cubic meters of waste air, an increase of 2.3

percent. According to Huang Qifan, Director of the Shanghai Economic Commission, "Pollution is still heavy. Technologies should be updated to reduce energy consumption".

However, government efforts to rationalize the collection of power related user fees may well be counter productive in the effort to promote energy conservation. Officials in Beijing recently announced the abolition of 560 electric power related fees, mostly collected by local authorities, According to the State Development Planning Commission (SDPC) the abolition of the fees is a step towards shaping a market-oriented pricing system for electricity. But, as the SDPC points out, the resulting lower cost of electricity is expected to stimulate power consumption and increase demand, particularly in rural areas; an effect that concerns proponents of energy conservation.

The Energy Conservation Law, and the subsequent regulations being drafted for Shanghai and other cities, also promote the use of clean, non-coal energy sources. Many such alternative energy sources are already established, and their contribution to the energy matrix is growing. The nuclear power industry is expanding; coal-bed methane is being harnessed as a new, clean technology; and natural gas, the current fair-child of the coal alternatives, is being piped into both Beijing and Shanghai to provide everything from domestic cooking fuel and heating to industrial power generation.

There is also strong support for the use of renewable energy alternatives such as hydro-electric power, solar energy and wind generated power. Shi Dinghuan, director general of the High and New Technology Development Division of the Ministry of Science and Technology said in his recent address to the China-European Union Energy and Sustainable Development Conference in Beijing that China has been acclaimed world-wide for its use of small-hydro power plants, of which there are nearly 7,000 in operation throughout the country. China also operates 6 million square meters of fixed solar panels, 40,000 square meters of solar heated greenhouses and 140,000 solar heated stoves. Wind energy projects in remote agricultural regions, mountainous areas and along the coast, generate a combined capacity of 50,000 kilowatts. Linhai, the largest wind power station in south China, located on the coast of Zhejiang province, supplies electricity to the southern reaches of greater Shanghai.

The continuing drive to introduce newer, cleaner and more energy efficient technologies to meet the country's ever-growing demand for electrical power is attracting interest from foreign suppliers of technologically advanced energy equipment. By way of examples, several U.S. companies are involved in the natural gas movement here in Shanghai, Atomic Energy Canada Ltd is supplying nuclear technology for a new power plant under construction in south east China, and elsewhere in the country wind powered generators have been imported from Dutch, Dannish and U.S. suppliers.

Patrick Jenevein III, president of the Texas-based Tang Energy Group, which is expected to invest US$40 million to build two wind-powered electricity generating farms in northwest China told China Daily recently that, considering the strong support of State policies governing renewable energies, such as wind-power, there are broad prospects for firms such as his here in China.

China is determined to introduce more foreign capital and technology to increase its proportion of cleaner energy sources, Wang Tao, vice chairman of the Environmental Protection and Resource Conservation Committee of the National People's Congress, told the China-EU Energy and Sustainable Development conference earlier this month. As China's population becomes wealthier the demand for manufactured products and electrical appliances is further fueling the nation's increasing demand for electricity. The demand will be met; the nation's huge coal resources will continue to be utilized; but at the same time efforts will continue to find cleaner production techniques and maximize efficient energy use. As potentially world's greatest producer of greenhouses gasses, China can not afford to let its demonstrated commitment to energy conservation lapse.

Sandra Cornell is a freelance journalist who lives and works in Shanghai, China.

Featured Essay - China's Environmental Regulatory System

Shaping an Environmental Protection Regime for the New Century: China's Environmental Legal Framework[1]*

By Zhang Hongjun and Richard Ferris, Jr.

* The third installment of a four-part series that discusses the state of environmental law in China. This part provides an overview of recent legislative reforms in China. The next and last part will provide an outline of concerns for foreign investors related to China's rapidly developing environmental legal regime.

To facilitate the transition to a more market-based economic system and enhance investor confidence, China is giving priority to the development of a legal and policy framework that demonstrates a commitment to the establishment of effective environmental protection laws and policies that function in a market economy. The country is now undergoing the laborious process of revising earlier statutes and regulations that do not adequately reflect social and economic realities.

Intense legislative activity in the area of environmental protection during the past decade has helped build a critical consensus at the top levels of the Chinese legislature that there is a need for environmental laws and policies that will not only protect public health and welfare, but will also preserve the country's resource base in favor of development patterns that are environmentally sustainable. As reflected in the Priority Programme for China's Agenda 21, organized in 1994 to implement the country's commitment to the United Nations Conference on Environment and Development, the NPC formally declared that preference will be given to the development of a comprehensive set of environmental laws and policies that can actually be implemented, enforced, and complied with as opposed to noble-sounding but hollow statute book laws."[2] As a result, China is trying to accelerate the pace of the environmental legislation and policy making process, while recognizing the need for a concurrent increase in implementation capacity.

Although not yet a routine part of the legislative drafting process, the views of foreign specialists are increasingly being sought by the Chinese government. Many of China's law drafting initiatives involve participation by foreign lawyers, scientists or other experts. This participation is often realized through the support of international institutions, such as the United Nations and multilateral or regional development banks. Although this is by no means an official method for input into China's legislative process, it represents a greater realization by China that it is not legislating in a vacuum and that any laws it passes may have profound effects on the international community and its own development success.

In order to spur the pace and efficacy of legislative drafting activities, China is undertaking massive procedural reforms. These reforms are geared toward the administrative structure reforms announced in March 1998. Before 1993, legislative drafts were prepared by different governmental ministries and agencies under the State Council, such as the Agriculture Ministry and SEPA. The drafts would then be reviewed by the State Council's Bureau of Legislative Affairs, which would in turn, consult other

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[1]This article is drawn from Zhang Hongjun and Richard J. Ferris Jr., *Shaping an Environmental Protection Regime for the New Century: Environmental Law and Policy in the People's Republic of China*, 6 ASIAN J. OF ENV'TL MGMT. 35 (1998) and Richard J. Ferris Jr., The People's Republic of China: An Environmental Law Briefing for Corporate Counsel, THE METROPOLITAN CORP. COUNSEL 13 (1997). Please note that, given the dynamic quality of the Chinese regulatory regime, certain information included in this article may have changed. Please feel free to contact Richard J. Ferris Jr. at rferris@bdlaw.com or the editors of Sinosphere should you need to confirm the current status of any of the legislative or regulatory initiatives mentioned in this article.

[2] See State Planning Commission and State Science and Technology Commission, Priority Programme for China's Agenda 21 (First Tranche) (Beijing 1994), at 1-1A.

governmental ministries and agencies depending on the subject matter of the proposed legislation. After approval by the State Council, the legislative draft would be submitted to the NPC for consultation and, potentially, passage into law.

The drawback of this legislative practice is that each government ministry or agency often attempted to assure that its own interests were reflected in the draft law. Thus, protracted negotiations frequently delayed the passage of legislation. Under this procedure, it is common for a piece of legislation to take several years to go from the governmental ministries or agencies charged with drafting the law to the NPC for final consultation.

In 1993, a more streamlined legislative procedure was introduced to provide a route by which primary drafting, consultation, and supervisory authority for certain areas of law would be accorded to special committees of the NPC. These committees would then prepare legislative drafts for review by the Standing Committee thereby by passing repetitive and time-consuming consultations with each and every subsidiary ministry and agency. In the NPC, there are presently nine such committees. Each committee has the power to draft or revise new legislation employing the technical expertise of specialists appointed as its members. Legislative drafts provided by the committees can be directly submitted to the Standing Committee of the NPC for approval and passage into law. Nevertheless, although the special committees can directly submit legislation to the Standing Committee during the drafting process, it is still common practice to obtain comments and suggestions from relevant government ministries and agencies. Thus, while drafting responsibilities are concentrated within the committees, involvement of ministry and agency representatives is still necessary to build sufficient consensus for passage and sound implementation of the legislation in question. The overall effect of the input of these committees, however, is that greater deference is accorded to the legislation drafted by the highly specialized committee members and a relatively faster track for the passage of legislation is established.

The committee with responsibility for legislation related to the environment was established in April 1993 and appropriately named The Environmental Protection Committee (EPC). The Committee was renamed The Environmental Protection and Natural Resources Conservation Committee in April of 1994, to better reflect the breadth of its tasks, although it is still commonly referred to as the EPC". The EPC is charged with the following responsibilities:

--Providing legislative proposals on environmental protection and natural resources conservation (EPNRC) to the Standing Committee of the NPC;

--Preparing draft revisions of existing EPNRC laws to the Standing Committee of the NPC;

--Reviewing legislative proposals from the State Council on EPNRC;

--Reviewing regulations from local congresses regarding EPNRC;

--Providing comments to other special committees of the NPC on their legislative proposals impacting on or related to EPNRC; and

--Supervising the implementation of EPNRC legislation by national government ministries and local government counterparts.

Thus far, the work of the EPC is quite promising. For example, the law and the Prevention of Environmental Pollution Caused by Solid Waste was first proposed in 1988. The proposal then foundered in various ministry and agency drafting committees for seven years. In the summer of 1995, the draft law was submitted to the EPC, was passed on October 30, 1995 and came into effect as of April 1, 1996. The Environmental Noise Pollution Control Law (1996) and the amendments to the Air Pollution Prevention and Control Law (1995) and the Water Pollution Prevention and Control Law (1996) were also drafted by the EPC.

Based on the grave need for environmental legislation that is better adapted to China's emerging market economy, and in light of the environmental media and related issues that are yet to be addressed by the current regulatory regime, the EPC submitted a Five-Year (1993-1998) Legislative Plan to the NPC in 1993. The Plan was approved shortly thereafter.

According to the 1993-1998 Plan, approximately seven environmental protection and natural resource conservation statutes will be created or amended by June of 1998, and a total of 17 such statutes will be created or amended by the end of the century. Thus far, EPC work appears to be progressing on schedule. Seven new or amended environmental protection and natural resource protection statutes will have been enacted by the close of the 1993-1998 Plan period in autumn 1998. Specifically, these statutes are: 1) the amended Air Pollution Prevention and Control Law (1995); 2) the Environmental Noise Pollution Control Law (1996); 3) the Flood Prevention Law (1997); 4) the Forestry Law (1998); 5) the Law on the Prevention of Environmental Pollution Caused by Solid Waste (1995); 6) the amended Mineral Resources Law (1996); and 7) the amended Water Pollution Prevention and Control Law (1996).[3]

As early as late-autumn of 1998, a new Environmental Legislative Plan may be announced by the NPC. This Plan, which is even more ambitious than the 1993-1998 Plan, will cover the 1998-2003 period. Presently, the NPC is soliciting recommendations from relevant ministries and agencies regarding legislation that should be drafted over the next five years. Soon after the new Plan is announced, the EPC will commence a new legislative drafting program based on the Plan. New statutes that may be proposed under the 1998-2003 Plan include: 1) a Clean Production Law; 2) an Industrial Waste Reutilization Law; 3) an Environmental Impact Assessment Law; and 4) a Renewable Energy Law. Added to these legislative proposals will likely be most or all of the amendments and initial drafts included under the 1993-1998 Plan that were not previously completed for review by the NPC. These include:

--The Chemicals Management Law (initial drafting process deferred for later consideration);

--The Desertification Prevention Law (initial draft);

--The Environmental Protection Law (amendment work underway);

--The Fisheries Law (amendment);

--The Grassland Law (amendment);

--The Land Administration Law (initial draft);

--The Marine Environmental Protection Law (initial amendment work underway);

--The Natural Resource Conservation Law (initial draft); and

--The Radioactive Pollution Prevention and Control Law (initial drafting underway).

China's legislators, law drafters and policymakers have determined that administrative responsibilities, internationally accepted environmental protection principles, administrative controls, and economic incentives should be considered in the initial drafting process and amendment of environment and natural resource legislation and policies. Accordingly, those interested in China's environmental protection regime may expect the following fundamental issues to be addressed in new or amended legislation:

1) Clarification of institutional responsibilities and liabilities arising from violations of environmetal protection and natural resources conservation laws;

[3] This number does not include the Energy Conservation Law, which was not included in the original 1993-1998 Environmental Legislative Plan.

2) Establishment of basic, internationally accepted environmental protection principles such as the Polluter-Pays-Principle,[4] the Preventative Principle,[5] the Precautionary Principle,[6] and provisions requiring violators of China's environmental protection laws to restore polluted areas to their pre-degraded status;

3) Incorporation of legal administrative controls, such as permits, registration and reporting requirements, and deadlines for compliance; and

4) Enhancement or addition of economic incentives, such as effluent fees, emissions trading, and pollution taxes.

[4] The Polluter-Pays-Principle requires that the costs of pollution prevention be borne by the polluter.

[5] According to the Preventative Principle, regulated entities should try to avoid environmental harms instead of combat the effects thereof. The principle requires, among other things, that the environmental impacts of projects be considered as early as possible in the planning process.

[6] Generally, the Precautionary Principle requires that action be taken, even in the face of scientific uncertainty, to control or reduce potential environmental degradation.

Featured Essays – China's Energy Efficiency Industry

Energy Conservation with Chinese Characteristics: An Update on Projects to Empower the Market

Jeffrey Logan[7]

Overview

Over the past two decades, China has achieved remarkable success in energy conservation. Energy intensity, a measure of the energy needed to drive economic growth, declined on average by almost 4.5 percent each year.[8] Most of the achievements resulted from command and control policies issued by the central government and implemented by provincial and local bureaus. These policies ranged from strict energy quotas for enterprises to low-interest loans for equipment upgrades and training for industrial energy managers. While China enacted these measures primarily to help bridge the gap between energy supply and demand, the environmental benefits cannot be ignored. Without these improvements in energy efficiency, China would be consuming about twice as much coal as it currently does.[9]

In the early 1990s, Deng Xiaoping accelerated the now familiar drive to institute a "market economy with Chinese characteristics." Central government support for some planning directives declined as many organizations and state-owned enterprises were encouraged to find their own solutions to budget needs. Some energy conservation programs were cut in this new environment. During this same period, however, price controls for coal and oil were relaxed or eliminated, increasing the incentive to conserve energy due to higher prices. Over the past few years, energy prices have stabilized, or in some cases, dropped, calling into question whether China can continue to maintain such a low energy elasticity.[10] The answer will depend on how successful China is in introducing more market-based incentives for energy efficient products and services.

In the mid-1990s, the government began instituting programs to empower the market for energy efficiency. One of the most attention-getting is a World Bank/GEF initiative to introduce for-profit energy management companies (EMCs) into China. These EMCs, referred to as energy service companies, or ESCOs, elsewhere, identify opportunities to upgrade equipment or processes in enterprises and finance the upgrades themselves. They recover their costs by sharing a portion of the monthly energy savings with the enterprise. The more energy the upgrades save, the faster the EMC gets paid back. Performance contracting as such has proved successful in North America and Europe, especially during times of rising energy prices.

Other examples of market-oriented energy efficiency programs include Green Lights, Energy Conservation in Township and Village Enterprises, Efficient Industrial Boilers, and a bilateral agreement with the US Department of Energy to address barriers in 10 areas. This paper will update readers on the progress of some of these efforts. Other important projects will be addressed in other sections of this newsletter or in future editions.

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[7] Jeffrey Logan works at the Battelle Washington Operations office in Washington, DC. Battelle operates Pacific Northwest National Laboratory for the U.S. Department of Energy.

[8] In the U.S., by contrast, the annual decline in energy intensity was 1.5 percent over the years 1977-1997.

[9] Although it is unlikely that China would have been able to produce and deliver an additional billion tons of coal each year.

[10] Energy elasticity here means growth in energy consumption divided by growth in the economy over two time periods. Over the past 2 decades, economic growth in China has been twice as fast as growth in energy consumption, giving an elasticity of 0.5.

China Energy Conservation Project

This $200-million project is introducing for-profit energy management companies into China for the first time. These companies are designed to overcome the two main barriers that inhibit greater investment in energy efficiency: 1) a lack of capital for project financing; and 2) a lack of incentives to improve efficiency. The EMCs identify enterprises that would benefit from more efficient equipment (or practices) and finance the upgrades themselves. Costs are recovered according to an agreement between the EMC and the enterprise indicating how the savings in energy costs will be shared. Ownership of the new equipment reverts to the enterprise after an agreed upon time has expired.

The project has two components: support for establishment and pilot demonstration of EMCs and support for proliferation of the EMC concept throughout the country. The World Bank, Global Environment Facility, and European Commission have provided loans and grants worth almost $100 million while the Chinese government has contributed an equivalent amount. The State Economic and Trade Commission (SETC) serves as the lead government organization while China's Energy Research Institute (under the State Development Planning Commission) and the Beijing Energy Efficiency Center (BECon) provide technical leadership.

EMC's were established in Beijing, Liaoning, and Shandong and began a phase of pilot operations in 1997. So far, they have initiated over 30 projects and have recovered about half of their original investments in upgrading equipment at state-owned enterprises. The project lines include: lighting, motor systems, boilers, electric arc furnaces, steam and air hammers, furnaces and kilns, power transformers, heat recovery, and district heating.

Most of the initial pilot projects began in June 1997 with a grant from the European Commission. A summary of the projects by company is provided below:

Beijing Yuanshan Energy Savings Company, Ltd. has invested $1.21 million in 12 demonstration projects. Through November 1998, the Beijing EMC had recovered over $150,000 of its initial investment through shared monthly energy savings. No operational problems have appeared and one has completely recovered its investment.

Liaoning Province Energy Conservation Technology Development Company, Ltd. has invested $1.38 million in 8 demonstration projects, and has recovered over 70 percent of its initial investments through shared energy savings. All projects are operating smoothly and two have completely recovered their investments.

Shandong Energy Conservation Engineering Company, Ltd. has invested $1.13 million in 10 demonstration projects and has recovered about 20 percent of its outlays. Two projects have completely recovered their investments and one has failed due to the host enterprise merging with another enterprise.

The information dissemination component provides information on the results of energy conservation projects to enterprise managers. The Energy Conservation Information Dissemination Center was established in January 1998 to lead this effort. It is a not-for-profit organization that operates under a performance contract with the SETC. Information is provided by the Center free of charge and it recovers costs based on how many enterprises use the information to implement energy conservation projects.

Over the past few years, interest rates for domestic loans have fallen sharply, making some enterprises reluctant to use EMC services when they could borrow the money and make the upgrades themselves. Educating enterprises of these options is a key role of the Information Dissemination Center.

EMCs have great potential to further accelerate the energy savings achieved in China over the past two decades, even if government budgets continue to shrink. Energizing the EMC market to improve industrial efficiency in China could be the most powerful tool to replace programs once run by the government.

China Green Lights

China now manufactures over 100 million compact florescent lamps (CFLs) each year, yet well over half are exported to other countries. The ones that remain in China are often of poor quality, and consumers are reluctant to spend extra money for a lamp that fails prematurely.

China established the Green Lights program in 1996 to address this problem. The UNDP provides a modest level of support (about $1 million) to engage international experts. The goals are to improve the manufacturing capacity for high-quality, economic lighting products (market push), while educating consumers about the benefits of using these money-saving products (market pull). Specifically, the project hopes to increase use of high-efficiency lights (CFLs and thin-tube fluorescent lamps) to 300 million units by the end of 2000. The project would save 22 TWh of electricity each year, avoiding the construction of 7 large power plants (7.2 GW of capacity). The environmental benefits of saving this much energy include annual reductions in sulfur emissions of 200 thousand tons and carbon emissions of 7.4 million tons.

The Green Lights project will address the barriers that prevent greater use of efficient lighting products. Efforts will focus on: developing improved standards and codes for lighting quality, educating the public (particularly large buyers) on the economic and environmental benefits of using energy-efficient lights, and introducing new financial mechanisms for green lights (soft loans for manufacturers to upgrade production facilities).

A permanent exhibition center was established three years ago in Beijing where over 60 manufacturers of high-quality, high-efficiency lighting equipment can display their products. Each fall, coinciding with the nation's energy conservation week, an international symposium is held to share information about similar efforts across the globe.

Sales of CFLs have more than doubled since 1996 when the program was initiated, rising to 37 million units in 1997.[11] Still, the image of CFLs as a low-quality product remains in the minds of many Chinese consumers, preventing greater use. Power tariffs have risen for many consumers, especially in commercial sectors, yet low prices in other regions inhibit greater use.

Energy Conservation and Pollution Control in Township and Village Enterprises

Township and village enterprises in rural China are growing rapidly, but continue to rely on inefficient, highly polluting technologies. They are responsible for about one-sixth of China's greenhouse gas emissions and use 30-60 percent more energy per unit of production than the country's already inefficient state-owned enterprises. This project, funded by the GEF and implemented by the UNDP and Chinese Ministry of Agriculture, targets TVE's involved in brickmaking, coking, metal casting and cement production. The primary objective is to remove barriers so that more energy efficient technologies are used. Project activities include technology demonstration, market development, regulatory transformation, financial and management training, and outreach. Implementation of the $1 million Phase I began in December 1997 and planning for a larger Phase II is underway.

[11] According to a newsletter from the International Association for Energy Efficient Lighting.

Sino-US Energy Efficiency Cooperation

This bilateral agreement was established in 1996 to promote opportunities for cooperative ventures in energy technologies and practices that have economic and environmental benefits to both countries. The U.S. Department of Energy and China's State Development Planning Commission are leading the activities. Ten teams have been established to address the issues in detail. The table below summarizes activities by each team.

Team Name	*Goal*
Energy Policy	Collaborate on policies to promote energy efficiency in China.
Information Exchange	Share relevant information and business practices through newsletters, websites, and publications.
Cogeneration	Promote cogeneration projects in China with US investors and partners.
Motor Systems	Facilitate the development and commercialization in China of high-efficiency motors systems.
Transformers	Raise the design and manufacturing level of transformers in China.
District Heating	Implement retrofits in district heating sites in China and document the experience.
Lighting	Provide technical assistance to the Green Lights program.
Buildings	Promote collaborative China-US activities to encourage energy efficiency in buildings.
Industrial Controls	Implement process improvements in different industrial firms in China and document the experience.
Finance	Identify issues constraining energy efficiency finance in China.

The teams have held a number of workshops, provided input for the creation of new regulations and policies, and demonstrated some technologies in the field. A complete update on the status of the project and summary of activities from each team can be found on the DOE's Office of Industrial Technologies' website (*http://www.oit.doe.gov/international/china.shtml*). Pacific Northwest National Laboratory also publishes a monthly newsletter with information about energy efficiency activities in China (*http://www.pnl.gov/china*)

Conclusions

Empowering the market to make investments in energy savings is critical for China to maintain its successful drive to save energy, improve economic competitiveness, and cut pollution. As the central government continues to play a smaller role in engineering China's economy, the projects described above are helping to build an energy conservation system with Chinese characteristics. The long-term success of this system, like economic reform in general, depends heavily on commitment from all levels of government.

Energy Development and Environmental Constraints in China

Lin Gan[12]

Abstract

This paper analyzes the inter-relationship of energy development and environmental constraints in China. It examines the effects of economic development, investment, energy trade and environmental constraints in shaping energy sector development. It highlights institutional tensions in energy development, energy conservation and environmental protection. It concludes that total fuel mix will be diversified in the future. China will become a big oil importer, due to increase in demand and resource limitations. Coal export will increase in the long run. SO_2 and CO_2 emissions will become larger in the future, because of the speed of economic growth and lack of effective control measures. Institutional bottlenecks, and political preference to solving local environmental problems, will undermine actions to eliminate global environmental risks. There exist huge investment potentials for energy development both from international and domestic private investment funds. Energy efficiency will continue to improve, associated with gradual decline of non-commercial energy use and increasing share of commercial energy in final consumption. Energy conservation holds the key for sustainable energy development, which should be promoted at the regional and local levels with demand management and end-use efficiency as the focus in policy implementation.

Note: The paper was published in *Energy Policy*, Vol.26, No.2, 1998, pp.119-128.

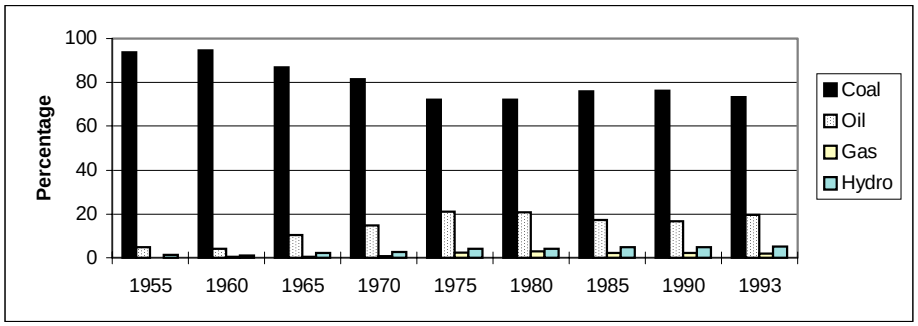
Introduction

China has experienced high rates for economic development in the past two decades, which has led to structural changes in the economy: from low energy intensive agricultural production to higher energy intensive manufacturing and social services. In the long run, the transition from traditional labor intensive agricultural production towards higher dependency on mechanization and intensive use of petroleum products will push the agriculture sector on higher demand for commercial energy-oriented development. It implies the diminishing use of biomass as the final energy source, and an increasing use of commercial energy, such as electricity, oil and oil products. Therefore, higher demand for energy services is inevitable.

Figure 1 shows the historical trends in the changing patterns of primary energy consumption. The absolute dominance of coal in primary energy consumption from the 1950s till the early 1970s was challenged by the increased domestic oil production output in the early 1970s, supported the discovery and exploration of huge oil fields in the Northeastern region. Coal consumption declined drastically in the 1970s, substituted largely by oil use. Oil was believed to have had abundant supply at the time and consequently stimulated demand increase. From the late 1980s, economic reform brought into a shape increase in energy consumption, particularly in the industrial sector. Oil supply was then constrained by production capacity limitations. Subsequent demands for energy would have to be met by increasing coal consumption, sustained by production capacity increases of private- and collectively-owned coal mines. The share of oil in primary energy consumption started to increase gradually, pulled by economic recovery from the recession in the early 1990s.

[12] Lin Gan is currently a senior research fellow at the Center for International Climate and Environmental Research in Oslo, Norway. He has recently accepted a position as the climate and energy officer of the World Wide Fund for Nature (WWF) in Beijing.

Figure 1. Primary Energy Consumption in China (1955-1993)

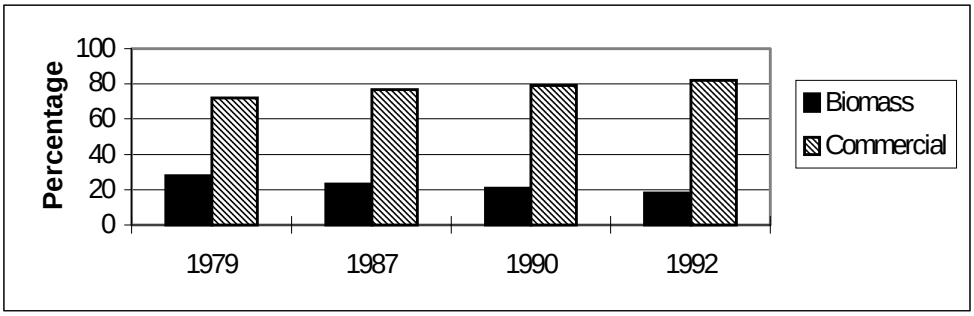


Source: Sinton, 1996, p.IV-13.

In the same period, natural gas and hydro electric power generation had been stagnating, due to the lack of investment funds and adequate policy incentives. These disparities in energy consumption patterns are very much shaped by resource availability and production capacity limitations. This situation is expected to change in the future. Natural gas development has been prioritized with the build-up of new infrastructure, i.e., pipelines to transport natural gas outputs from newly developed offshore and inland fields. Hydro power development is symbolized by the Three Gorges Dam construction. The long-term trend in energy consumption tends to shift toward diversification. Natural gas, nuclear power and hydro electricity will come to take larger shares in final energy consumption. However, the share of coal in primary energy consumption may still increase in the near term till 2020, and decrease thereafter. The timing for change in consumption patterns, especially in coal use, depends, to a large extent, on how environmental externalities are incorporated into public policy-making, so are reactions of the general public to health-related coal use.

The trend in primary energy consumption indicates a continuous decrease in biomass consumption, as seen in Figure 2., From 1979 to 1992, consumption of biomass energy, including firewood, crop stalk and dung cake, decreased from 28% till 18% out of the total primary energy consumption. By contrast, use of commercial energy increased from 72% to 82%. This trend is consistent with the assumption made in the IIASA-WEC scenarios across regions of the world (IIASA-WEC, 1995, p.vi). In urban residential areas, population with access to gas for cooking, including natural gas and coal gas, has increased from 16.8% in 1980 to 61.7% in 1994 (State Statistical Bureau, 1995, p.314). Clearly, gas has increasingly replaced coal as a fuel for cooking in urban areas.

Figure 2. Commercial and Biomass Energy Consumption in China (1979-1992)



Source: Sinton, 1996, p.IV-16.

From 1980 to 1993, China experienced a constant decline in energy intensities with an average of 4.5% annually. In the same period, primary energy consumption increased 5.1% annually, while GDP raised 9.6% per year. This trend reflects the structural and technological changes in sectors of the economy. A number of combined factors contributed to the overall improvement in energy intensities: shift in industrial structures toward less energy-intensive sectors, improvement in production efficiency and management skills. Increasing international investment in industry has brought about not only financial resources, but

also new technologies and devices, which contribute to efficiency improvement in final energy consumption. However, the energy intensity of GDP in China is still 6 times higher than that in OECD countries, and 2 times higher than that in India (Wu, 1994, p.907). The potentials for continued improvement in energy intensity is foreseeable, but the pace of energy intensity improvement will slow down, due to structural bottlenecks. Further decline in energy intensity depends on market adaptation and diffusion of new technological innovation, production process rationalization and end-use efficiency improvement in the industrial and commercial sectors. Diffusion of new energy efficient technologies based on market competition holds the key in energy efficiency improvement.

A general trend is that energy structure will shift from coal domination till increasing share of hydroelectric and nuclear power, and new and renewable energy sources. According to a study from Tsinghua University, China, after 2020, the share of coal in primary energy supply will decrease from the current 75% to about 50%, and the share of hydropower and nuclear in electricity generation will increase from less than 5% to about 20%. By 2050, per capita energy consumption will be around 2-2.5 Tce (He, 1996, p.253).

Investments and Financial Mechanisms

Gross domestic investment as percentage of GDP in China was 35% in 1980 and 40% in 1995. This is partly due to high private savings rate. China had an average gross domestic savings rate of 35% of GDP in 1980 and 42% in 1995 (World Bank, 1997, p.238). Hong Kong had an average savings rate of 31% in the 1980s (World Bank, 1996, p.212). This can be compared with the world average savings rate of 21% in 1995 (World Bank, 1997, p.239). There exists a big potential to mobilize private savings from capital market for energy sector finance.

During 1980-1990, energy investment as a share of public sector investments in China was about 23%, of which 52% was invested in electric power generation, and the rest in oil and coal sectors (State Statistical Bureau, 1992, pp.28-29). The share of energy sector investment in total public investment is declining. In 1993, it was 20%, compared with 29% in 1990. Total public energy sector investment was at 85 billion yuan ($17 billion) in 1990. This figure had grown till 150 billion yuan ($26 billion) by 1993. This is a fast growth, as total investment increased 50% in 4 years (Sinton, 1996, p.III-12). More capital is being allocated to the energy sector, mobilized from collective- and private-owned industries. At the same time, state investment as a share of total energy sector investment is declining constantly from 65% in 1990 till 61% in 1993.

In the last decade, most energy investments came from public sector finance. Foreign private investment in the energy sector did not exist before 1990. It was only from the last few years that FDI in energy had grown substantially. This is mostly because of deregulation in the energy market and incentives provided by state investment policies. Due to public sector deficit, shortage of founds will be a major bottleneck. A shift toward mobilizing more private funds and foreign capital is inevitable. In this process, governmental policy could play a central role in shaping investment priorities. The main driving force in determining investment priorities will be the relative rates of economic returns for investment.

We have observed two diverging trends in energy sector investment: a steady decline of state investment in coal production from 26-29% in the early 1980s to about 15% in recent years; and an increasing share of investment in electric power generation from 34% in 1981 till 50% in 1993 (Sinton, 1996, III-14).

Investment in energy conservation has been in average at 8.7% of the energy investment in the 1980s. 90% of the state investments were concentrated on building up production capacity. There is a favor of state planners who tend to support large-scale energy project development. Support for energy conservation is weak at the local and enterprise levels. This is a discouraging factor in attracting investment for small-scale, cleaner, and energy efficient technologies. Compared with investments in other sectors, such as consumer goods production and infrastructure development, which usually yield higher rates of return over investment, energy conservation is unlikely favored by most investors, unless strong policy support is in place.

Most energy investments come from domestic sources, and the rest should be met through international finance. There is an indication that FDI is taking an increasing share in domestic investment in recent years. It has grown from 13% in 1993 to 19% in 1996. FDI is by far the main engine for economic growth. China has been particularly successful in attracting FDI, accounting for over three-quarters of the increase in investment flows into Asia and the Pacific region during 1991-1994. China has become the second largest recipient of FDI in the world since 1993, after the USA. During 1985-1996, FDI in China had grown from $2 billion to $40 billion. It is expected that FDI will increase to $50 billion in 1997 (UNCTAD, 1995, p.54).

Private domestic investments in energy have been the main driving force in coal mining. From 1980-1992, output from small local coal mines accounted for 67% of the total increased output nationwide. The share for the total output from collective and private mines changed from 45% in 1980 to 56% in 1992. This trend is further encouraged by deregulation in the energy sector. The general trend in the energy market is the decreasing role of the state investment, and the increasing performance of local governments and the private sector financing (Yan, 1994, p.2).[13]

We expect a freer market for energy production and trade. China currently has the share of 13% of the global capital flows (The World Bank, 1996, p.136). There will be more private investment in the oil and gas sector, such as on offshore oil and inland gas exploration projects. Coal resource exploration and production will be less attractive to private investors, due to thin profit margins. We have seen a growing interest of foreign investors in electric power plants.[14] This disparity in investment may lead to coal shortage problem in the power sector in the long run. Rationalization of energy prices through increasing market competition will be a key factor to encourage more private investment inflows.

International development assistance plays an important role in China's industrialization. ODA may not be able to grow substantially in the future, due to financial constraints in the UN system and in most bilateral aid agencies. In the past decade, about 20% of ODA were invested in the energy sector, mostly in production capacity building. It is expected that stronger support for the environment and energy conservation from ODA will be provided, and meanwhile, prospects for investment increase in the supply side will be modest (Gan, 1997).

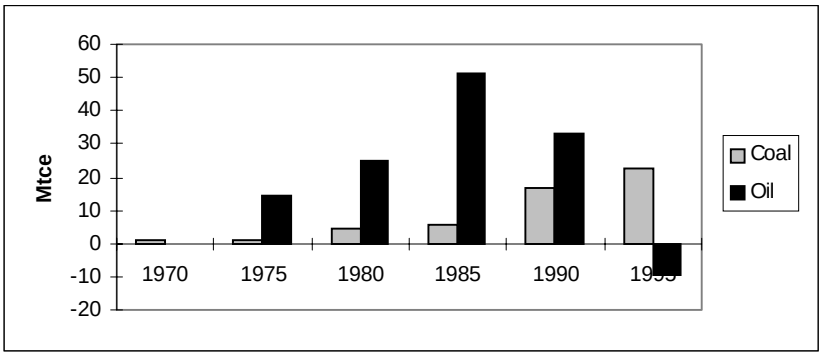
Energy Trade

There have been two grand transitions in China's energy trade: increase in coal export, and decrease oil export. As shown in Figure 3, from 1970 to 1995, coal export increased from 1.3 million tons to 22.6 million tons. In oil trade, oil export increased steadily throughout the 1970s and peaked in the mid-1980s. There was a continuous decline in export thereafter. By 1993 China became a net oil importer and oil import reached 9.4 million tons in 1995. This is an important change in energy trade, indicating that China may become highly dependent on imported oil to sustain its industrialization and economic growth in the coming decades (Yan, 1994, p.154; *China News Digest*, Jan.14, 1997).

Figure 3. Net Energy Export of China (1970-1995)

[13] One example is the private fund raising for the Three Gorges Dam Project. In 1997, $120 million bonds were issued to help finance the construction of the dam. The three-year bonds were sold out within five days (*Greenwire*, Feb.28, 1997).

[14] One example is the Yangtze River basin where foreign utilities companies are attracted to invest in building up electric power plants. By 1994, total investment amounted to more than $ 1 billion with the total generating capacity of 4.1 GW (*People's Daily*, July 26, 1994, p.1).

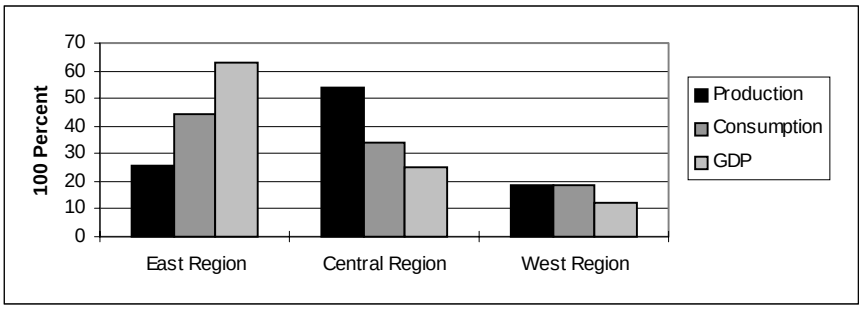


Source: Sinton, 1996, p.VII-4; BP, 1996, p.19.

Two factors are related to these changes. The first is the growth in demand. Transportation sector growth is one example. Passenger transport increased 2.5 times during 1980-1995. Road transport accounted for 65% of the total passenger transport capacities in 1980. It increased to nearly 90% by 1995. It implies an increasing dependency on automobile as means of passenger transport. The similar situation is seen in freight transport, through which 76% of goods were transported by road in 1995, increased from 69% in 1980 (State Statistical Bureau, 1996, pp.94-95). The second factor is the diminishing dependency of oil export as means of foreign currency earning, as manufactured products have replaced oil export as the major foreign currency earner. Very strong demand is pushing oil price higher in domestic markets, which has disinterested oil sells to international markets.

China will have to rely on imported oil and products in the future, as China has a uneven distribution of energy resources, i.e., high energy production capacities and low energy consumption level in the Central region. By contrast, there are energy deficits in the coastal areas of the East region with higher levels of industrialization and energy consumption (see Figure 4.). Potentials exist to import natural gas from the Far East region of the Russian Federation to the Northeast region, such as Liaoning Province, with high concentration of energy intensive industries. There are also opportunities to import liquefied natural gas from the Middle East to the Southeastern region in China.

Figure 4. Regional Comparison of Energy Production, Consumption and GDP in China in 1990



Source: State Statistical Bureau, 1992, p.17.

China's growth in GDP per capita and foreign-exchange reserves are likely to continue,[15] which could enable China to import more oil to meet high energy demand and substitute for coal use. From the environmental point of view, fuel substitution will permit China to reduce carbon dioxide (CO_2) emissions, as well as sulfur oxide (SO_2) emissions, so to reduce health effects and potential conflicts between nations in the Southeast Asian region.

[15] China's foreign-exchange reserves reached a record high by January 1997 with a total $ 110.6 billion, which was the second largest in the world after Japan. See: *The Economist*, April 12-18th, 1997, p.120.

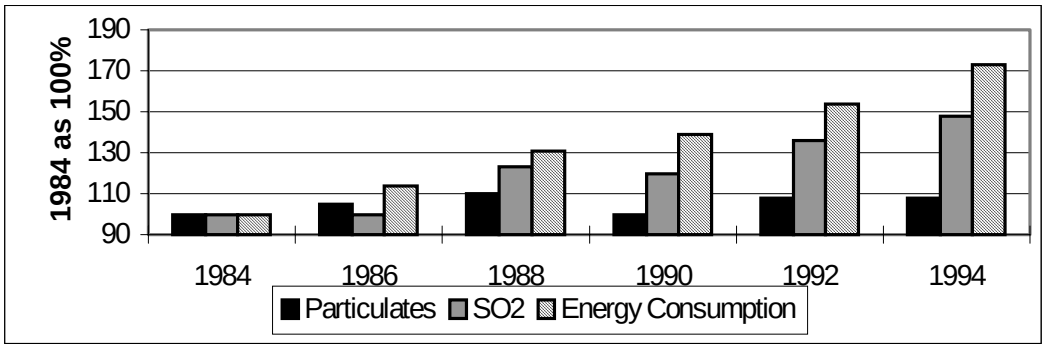
Environmental Constraints

Environment protection is evolving into a critical factor in determining the rates of economic growth and energy sector expansion. Energy consumption is increasingly shaped by environmental regulations. So is behavioral change of consumers with growing environmental consciousness. There will be an increasing influence of non-governmental organizations (NGOs) on environmental protection, supported by the emerging middle-class who tend to care more for the environment. It is expected that severe environmental damages in ecosystems and human health will lead to stronger environmental regulations (*China Environmental Yearbook*, 1995, p.94).

The main issue is the extensive use of coal. Pollution caused by direct use of coal, such as SO_2 emissions, might reach the critical levels that could go beyond the acceptability of the general public. Health effects of pollution may evolve into a strong social critique, and public protest. Environmentally related public hearth problems have already drawn attention of the government. There are also potential regional and international conflicts, concerning long-rang transport of pollutants (Liu, 1993). Local environmental pollution could be weighted more than global environmental problems from public concern. Measures to reduce local and regional environmental pressures, e.g., SO_2 emissions, may gain stronger public support than global environmental issues, e.g., CO_2 emissions reduction.

Another issue is air pollution, e.g., SO_2 and particulate emissions. Figure 5 indicates the trend of emissions increase during 1984-1994. Particulate deposition has been more or less under control with slower increase in early 1990s. It reflects the fact that more control measures are undertaken in industry to reduce particulate emissions. It also indicates the relatively low costs of reducing particulate emissions, especially for particulates removed during noncombustion processes. Further improvement may become more difficult, due to financial constraints and enforcement of the existing emissions standards, especially in small-scale rural industries. In residential areas, particulate emissions reduction related to direct-use of coal in households depends largely on fuel switching, i.e., from raw coal to coal briquettes, and from coal to gas and electricity.

Figure 5. Energy Consumption, SO_2 and Particulate Emissions in China (1984-1994)



SO_2 emissions have closely followed the trend in energy consumption. The main reason to explain the high growth rates in SO_2 emissions can be attributed to high costs of emissions control technologies and equipment. Coal washing is an important measure of removing sulfur dioxide (SO_2) from coal. Currently, only 14% of raw coal are washed and there was a decline of investment in coal washing capacities in the past decade. In addition, stack removal of SO_2 has been little practiced. These are the major causes to the increasing SO_2 emissions. SO_2 emissions will follow coal-use patterns closely, if no radical policies are introduced to regulate SO_2 emissions.[16] Compared with eliminating particulate from coal use, reduction of

[16] From 1993, SO_2 emissions tax was introduced in 2 provinces and 9 cities in China, regulated by the Environmental Protection Committee of the State Council, which equaled to 20% of the total costs for SO_2 removal (*People's Daily*, June 3rd, 1993, p.3).

SO_2 emissions will be more difficult to implement. In 1990, SO_2 Emissions in China already reached 15 Mt (Sinton, 1996, p.VIII-11), and increased to 18.3 Mt in 1994 (*China Environmental Yearbook* 1995, p.426).

The Role of Institutions

During 1985-90, 300 billion yuan ($62.7 billion in 1990 dollar) was invested in energy sector development. In energy conservation, only some 4.7 billion yuan ($1 billion) was invested in technical innovation, and 11.4 billion yuan ($2.4 billion) for capital construction (1.6% and 3.3% of the total investment, respectively). The majority of the capital was used for increasing energy production outputs (Mao, 1992, p.91). In the clean coal sector, recent years have seen a drastic decline in capital investments in coal washing and separation.[17] From 1987 to 1990, capital investment in coal washing and separation dropped from 4.2% to 1.3%, i.e., from 253 million yuan ($52.9 million) to 100 million yuan ($20.9 million), as a proportion to the total investment in the coal industry. Meanwhile, investment in coal production increased by 71% from 5.7 billion yuan to 9.8 billion yuan (State Statistical Bureau, 1992, p.27).

Energy conservation in the early 1990s has evolved higher in policy agenda, and become the top priority in energy policy, partly as a result of increasing environmental awareness and pressure. Environmental agenda become more complex in implementation, compared with the early 1980s. Energy conservation has transformed the values and attitudes of many policymakers, and the behavior of governmental institutions. The government has developed a long-term vision of conservation objectives and the potential measures to be reinforced, including reinforced regulatory and financial instruments (*China Macro-economy*, April 25, 1997). The policies developed have covered almost every sector of the economy. The inception of global environmental protection in national policy-making has given rise to a new dimension in energy conservation.

Financial sectors were mobilized to provide resources for energy conservation projects. This includes soft loans, tax deduction or exemption for producing energy saving equipment and products and for importing energy efficient technologies. During 1980-90, investments in energy conservation totaled some 20 billion yuan ($4.2 billion), which led to an annual 50 Mtce (million tons of coal equivalent) in energy saving capacity.

Another impact of energy conservation policy is on industrial behavior. Many industrial enterprises, particularly large state-owned companies, have for a long time been reluctant to technological change, due to the lack of incentives, disincentives, and market competition. Pushed by energy conservation policies, industries have come to realize the rational to invest in energy saving technologies and end-use efficiency (Ministry of Energy, 1992).

Conclusions

China is in a period of rapid transition in development. Although uncertainties and tensions are perceived, there are positive signs of development. Main issues in the energy sector in the future will be how to balance energy development with environmental protection and resource redistribution. Several issues are important in energy policymaking and implementation: first, total fuel mix will be diversified in the future. The share of coal in primary energy production and consumption will increase by 2020 and diminish gradually thereafter, to be replaced largely by natural gas, nuclear and renewables; second, China will become a big oil importer and coal exporter; third, SO_2 emissions will become large in the near future, because of the speed of economic growth and lack of effective control measures and investments; fourth, CO_2 emissions will increase to a large extent, however, measures to reduce CO_2 emissions are unlikely to be effective in the near future, because of economic and institutional bottlenecks, and political preference to solving local environmental problems; fifth, there exist huge investment potentials for energy development

[17] Technical processes to reduce the ash content of coal which can subsequently lessen the burden on transportation systems and increase coal combustion efficiency. Thus coal washing and separation can serve two objectives of energy efficiency improvement and environmental protection.

both from international and domestic private investment funds and, meanwhile, the role of official development assistance will not be substantial; sixth, energy efficiency will continue to improve, associated with gradual decline in non-commercial energy use and increasing share of commercial energy in final consumption; and finally, energy conservation holds the key for sustainable energy development which should be promoted at the national and local levels with a focus on demand-side management. To achieve conservation objectives, cost-effective financial and regulatory instruments need to be further developed and implemented.

Rational and Clean Coal Use in China

Lanqing Jia[18]

Preface

China is rich of coal and with high-approved reservation, 90 percent of the total approved reservation of fossil energy. Coal has been dominated in China's energy production and consumption for a very long period. At the beginning of New China, coal accounted for 96 percent of the energy production and 94 percent of energy consumption. In 1995, the production of raw coal in China was 1.36 billion tons, 75.5 percent of the total primary energy production and 75 percent of the total primary energy consumption. Coal provided 75 percent of the fuel and power of industry, 76 percent of the electricity, 80 percent of the utility and 60 percent of raw materials in chemical industry. It is estimated that coal will account for 2/3 of China energy consumption in 2010. With the constrains on hydro-power and other renewable energy sources, whose development intensity is still very limited, coal will remain the main energy source in China. The dominance of coal in energy mix cannot be changed in near future.

Heavy pressure on environment from coal utilization

A. Environmental impact of coal mining

By the end of 1990, 0.3 million hectare of land sinks due to coal mining, 1/3 in plain area. The additional sinking area is increasing at a rate of 13300 to 20000 hectares per year. The accumulating solid waste from coal mining reaches 3 billion tons, which occupy 12000 hectares of land; the increasing rate is 0.13 billion ton per year. The utilization rate of coal waste is only 36.2 percent. Spontaneous combustion of coal waste generates huge amount of SO_2, CO and H_2S emissions, which cause serious air pollution. Moreover, huge amount of slurry water from coal mining was emitted every year. The leakage of coal-bed- methane along with coal mining cause environmental pollution as well.

B. Environmental pollution from coal combustion

China coal resources have the following characteristics: the majority of coal resource is with high ash and sulfur content, which is difficult for washing. Coal direct burning is the main pollution source of particle material and SO_2.

C. Low efficiency in coal utilization cause energy wasting and pollution

In China, coal consumers are very diverse and the efficiency of coal utilization is very low, which is very different from those advanced countries whose coal is mainly used for power sectors. Among the coal consumption in 1995, 37 percent is for electric power generation and heating, 14 percent is for coke making and gasification, 10 percent for living. 86 percent of coal was burned directly.

The current efficiency of coal utilization in China is much lower than advanced countries. China industrial boilers are 15 percent to 20 percent less efficient than those in advanced countries are. The heat rate of Chinese power plants is 25 percent higher than that in advanced countries. The average efficiency of coal utilization for residential living is only 25 percent to 45 percent of that in advanced countries.

The Necessity of the Clean Coal Technologies (CCT) development

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The dominance of coal in China energy consumption will not change fundamentally for a long period. According to " the Ninth Five Year Plan of Energy Development and Prospects of 2010", both coal production and consumption in 2000 and 2010 will increase greatly comparing to current levels. Therefore, the environment pressure will be heavier and heavier from coal mining, conversion and utilization, which will conflict with stricter environment protection standard. In order to achieve sustainable development of economy and society in China, it is very necessary to develop clean coal technologies with Chinese characteristics.

Many counties take coal as the main alternative energy resource of oil because coal content in world energy consumption is relative high (30 percent) and its reservation is abundant. Therefore, many countries also pay great attention on CCT in the field of energy and environment. CCT is one of the leading technologies in achieving the coordinate development of energy, economy and environment.

Rational coal utilization

There are many different types of coal in China. In terms of volatile content, China has anthracite with very low volatile content, as well as lignite and peat with extremely high volatile content, including the coke coal for metallurgical industry. In terms of ash content, China has high quality coal with very low ash content, as well as low quality coal with high ash and moisture content. In order to achieve clean and efficient coal utilization, the following characteristics of coal should be considered:

- Coal quality: volatile content, ash content, sulfur content, size distribution, grinding factor, and ash melting temperature;
- Coal transportation: reduce the load of coal transportation through coal screening and washing, coal transportation or power transmission;
- Energy efficiency of coal utilization: decentralized or centralized district heating; cogeneration or condensed power plant;
- Environment protection: coal preparation, clean combustion and desulfurization technologies.

Rational coal utilization according to coal quality

In advanced countries with hundred years of experiences of coal utilization, many problems have been solved. In United Kingdom, there are articulated regulations on coal ash content and size distribution although it has only several types of coal. Washed coal with low ash content is transported to the boilers around urban areas. Coal with average ash content is transported to power plants as their fuels. Coal with high ash content is burned in mine-mouth power plants. The coal waste during coal washing is returned to reclaim the coal mines. China can adopt the same methods in coal utilization, the following should be paid more attention:

Coal size distribution and ash content

Construct coal screening facilities at the mine mouth, and burn high ash content coal in mine mouth power plants. Generally coal ash exists in large-sized and fine particulate of coal, which should be used around mine mouth so as to reduce transportation load, as well as to reclaim the land for coal mining. China has grasped the technologies of burning low-grade coal in circulate-fluidized-bed boilers. Additional investment of constructing coal-screening plants can be compensated with the cost reduction of transportation and land conservation if coal ash is transported to urban area.

The medium-sized coal with low ash content need further cracking and screening. The coal with grain size larger than 10mm is suitable for industrial boilers whose capacity is lower than 10 tons per hour. The coal with grain size between 0.1mm to 10mm should be sent to CFB boilers nearby. The fine coal should still go to mine-mouth boilers or other pulverized-coal boilers. This will reduce the energy consumption of coal preparation, and increase combustion efficiency as well.

Volatile content

Coal with high volatile content and low sulfur content should primarily go to metallurgical and coal-gas industry rather than burning directly. Former Soviet Union once adopted a policy that coal could only be burned directly when it is not suitable for other purposes.

Coal washing

The cost of coal washing is relative high regarding the low price of raw coal. However, if considering the cost of transportation and land occupation of coal ash and waste, the additional cost of coal washing is reasonable. Through washing process, 80 percent of coal ash could be get rid of. Advanced coal washing technologies can also eliminate other dangerous chemical element, such as S, As, and Hg.

The sulfur content of coal should be justified by its heat value. For example, coal A and coal B has the same sulfur content, but the heat value of coal A is only half of coal B, the SO2 emissions of coal A could be twice of coal B to get the same amount of heat. In China, the sulfur content of coal being burned in some power plants is very high, if the sulfur could not be eliminated through coal washing, its sulfur content could be 8000 to 20,000 mg/Nm^3 in terms of per thousand billion joules. Obviously, it is extremely polluting to burn such kind of coal without washing. The utilization of high sulfur and low heat value coal should strictly prohibited unless proper measures are taken in flue gas desulfurization.

Combustion technology selection according to coal quality

With the rapid development of electric power industry this century, coal combustion technologies are developed greatly as well, from chain stokers to pulverized-coal boilers. In recent years, new development of coal combustion technologies are achieved due to the stricter requirement of environment protection. So-called clean coal combustion is appeared. It is very important to select combustion technology properly according to coal quality. Table 1 summarized the coal quality requirements of different coal combustion technologies.

Table 1 - Coal Requirements for Combustion Technologies

Method	Boiler Capacity [t/h]	Size distribution	Grinding factor	Ash content (percent)	Ash melting temperature (°C)	Sulfur content (percent)
Chain Stoker	<45	Lump coal	NA	low	NA	Low
Pulverized Coal Boiler	>2000	Fine coal	high	low	>1150	Not too high
FBC	35 to 1000	Average size with low content of fine and lump coal	NA	high	NA	Can be a little bit higher

From Table 1 we know that different combustion technologies have different requirements of coal particulate size. Currently in China, raw coal goes to boilers directly from the coal mines without screening, which cause both low efficiency and high pollution. For example, fine coal is not suitable for chain stokers, only lump coal can be burned relatively completely in them. The coke-binding ability of the coal should not be either too high or too low otherwise if too high coal will be combine together after entering the high-temperature zone of the boiler, which will cause incomplete coal combustion; if too low it will broken after being heated, which will increase the unburned carbon content in sludge and fly ash. Moreover, if the size of the coal is not even enough, the pressure loss across the coal layer will be uneven, which can cause incomplete combustion as well.

For pulverized-coal boilers, extremely fine coal are needed at 15 to 30 kWh grinding energy consumption per ton. If the coal size is too big, it needs cracking down before grinding, which consume additional energy. If ash content in the coal is high, it means unnecessary energy is consumed to grind the ash. If the ash melting temperature is low, they will slugging on the internal side of the boilers, which could seriously affect the

normal operation of the boiler. If the ash content is too high, when they pass through the heaters and re-heaters of the boiler, they will damage the tube surface of these heaters. Therefore, pulverized coal boilers need fine coal with average hardness, low ash content and high ash melting temperature.

Circulate-Fluidized-Bed (CFB) boilers are becoming more popular in China as one type of clean coal combustion technologies. The combustion temperature of CFB boilers is low, around 850 to 900 °C. Limestone can be injected in the combustion bed as well. Therefore both NOx and SO_2 emissions are less than pulverized-coal boilers. Moreover, the coal with low ash melting temperature can also be burned in CFB boilers regarding its low combustion temperature. Due to the high heat capacity in CFB, even anthracite and petcoke can be burned easily in CFB. Fine coal is not suitable for CFB boilers because it can not be collected and re-burned efficiently, otherwise the heat loss of fly ash will be very high once being used. Moreover, large amount of solid is needed to circulate between the combustion bed and particulate separator so as to maintain the stability of combustion. Therefore average-sized coal with high ash content is more suitable for CFB boilers, which happen to fill the gap between chain stokers and pulverized-coal boilers regarding the requirements on coal particulate size.

Other solutions of coal rational utilization

A. Co-generation
Co-generation plants for district heating and power supply should be widely adopted to replace tremendous amount of small boilers with low efficiency and high emissions, which can sharply reduce coal consumption for power and heat supply, as well as reduce emissions.

B. Develop advanced clean coal technologies for power generation
The capacity of CFB boilers should be further increased so as to catch up the world level. More favorable policy for adopting domestic CFB boilers should be enforced. The demonstration projects of advanced power generation technologies, such as IGCC (integrated gasification combined cycle) and PFBC (pressurized fluidized bed combustion), should also be paid enough attention.

C. Flue gas desulfurization (FGD) technologies
Most FGD technologies currently available are too expensive for China to adopt widely even many Chinese coal are high sulfur-content. It is very urgent to develop domestic FGD technologies with low-cost and high-efficiency. LIFAC technology (Limestone injection into furnace and Calcium Oxide Activation) is one of the most promising domestic technologies developed by Tsinghua University at Beijing.

D. Other clean coal technologies
There are many other clean coal technologies besides clean coal combustion, such coal gasification, coal liquefaction (direct and indirect), coal-oil combined refinery, advanced clean coke production, and coal-based methanol production. The comprehensive utilization of the by-products from coal mining, combustion or conversion are another part of clean coal technologies, such as coal mine waste, coal-bed methane, coke-oven gas, coal ash, and FGD waste. A development strategy on clean coal technology should be formulated and implemented.

Following the requirements of the State Council, the related commissions and ministries agreed to set up " the National Clean Coal Technology Implementation and Planing Leadership Group". The Group was chaired by the State Development and Planning Commission (SDPC). The Ministry of Science and Technology (MOST) and State Economic and Trade Commission (SETC) are co-chairs. The formulation of the national strategy on CCT was initiated right after the establishment of the leader group. Based on the individual plan from each participant ministries and commissions, the State Planning Commission finished the draft of " The National Ninth Five Year Plan for the Clean Coal Technology and the Long Term Targets for the Year 2010". The CCT Advisory Group was set up at the same time, whose members are the well-known experts from different CCT fields all over the country. After being reviewed by the members of the Leader Group and the Advisory Group, the draft plan was submitted to the State Council. In April 1997, the State Council approved the plan and authorized the CCT Leadership Group to coordinate the implementation of the Plan, which marked the

first CCT strategic plan was originated and implemented in China. From then on, the development of China energy technologies entered a new historical phase.

China Environment Briefing

By Changhua Wu[19]

China's Top Ten Green News Stories of 1998

The following list represents China's most important environmental news stories for 1998. The list was organized by the World Wildlife Foundation (WWF) and China Green Times (CGT).

1) In January, 151 scholars form the Chinese Academy of Sciences and the Chinese Academy of Engineering called for immediate actions to save the Yellow River.

2) The new Forestry Law was published in May.

3) In October, China launched its Natural Forestry Protection Project.

4) In December, leaders of the Chinese central government gave instructions on improving Beijing's air quality.

5) In November, the Chinese State Council approved the All-China Biological Environment Construction Plan.

6) In September, Premier Zhu Ronji praised Ma Yongshun for his transformation from a lumberjack to a tree-planting hero.

7) In June and July, severe flooding drew the attention of all Chinese to the nation's environmental problems.

8) In August, the Chinese State Council issued an emergency notice forbidding the felling of trees for cultivation and the misappropriation of woodlands, marking the start of a trans-century green protection action.

9) In April, Beijing saw a muddy rain due to sandstorms in the north.

10) In February and March, people in China and around world took an interest in the protection of the endangered Tibetan Chiru.

"Blue Sky Project" Aims to Tackle Deadly Beijing Air

In response to a report blaming local air quality for an increase in the city's death rate, Beijing's Environmental Protection Bureau has launched an aggressive campaign to regulate local coal burning and vehicle emissions. The "Blue Sky Project" was developed after a joint study by Harvard University and Beijing Medical University found that poor air quality has resulted in a 4 percent increase in the Chinese capital's death rate. The project calls for the establishment of 40 coal-free regions in the city by the year 2000. *(1.9.99)*

Officials Meet to Discuss Alternative Uses for Garbage

Officials from regional scientific and technological urban construction administrations met in Guanghan, Sichuan Province, on January 13, for the opening of a national conference on the treatment and utilization

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of urban garbage. The conference itself represents an increased awareness of the necessity for China to develop environmentally sound treatment and burying methods for its quickly-growing piles of urban garbage.

In 1997, the per capita annual garbage production for China's cities was 440 kilograms (970 pounds), with that number increasing 8 to 10 percent annually. Last year, the government allocated an additional 2 billion yuan (US $241 million) for garbage treatment. *(1.14.99)*

Red Tides Take Heavy Toll on Guangdong Province

Red tides, so named for the discoloration of the seas resulting from periodic outbreak of toxic organisms called dinoflagellattes, cost Guangdong Province 40 million yuan (US $4.8 million) in April, 1998 alone. The economic toll was due to the loss of roughly 400 tons of aquatic products killed by the oceanic phenomenon. Experts blame "El Niño" for the frequent occurrence recently of red tides in Guangdong. *(1.15.99)*

Cleanup Job Underway at Yunnan Lake

A pollution control project has commenced at Dianchi Lake in China's southwest Yunnan Province. The lake project was listed as one of the key elements of the government's "Three Rivers and Three Lakes" project, and will cost a total of 3 billion yuan (US $361 million), with US $150 million coming in loans from the World Bank. The cleanup comes as the provincial capital, Kunming, prepares to host the World Horticulture Exposition this spring.

Dianchi Lake covers 307 square kilometers and plays a vital role in the area's ecological balance. The "Three Rivers and Three Lakes" project includes the Liaohe, Huaihe, and Haihe rivers, and the Taihu, Chaohu, and Dianchi lakes. *(1.16.99)*

Polluting Factories in Henan Closed

In a move consistent with the national government's "Three Rivers and Three Lakes" environmental protection initiative, the city of Shangqiu, Henan Province, has shut down two polluting factories and blocked a water diversion ditch, all of which were polluting the Huaihe River. The Yellow River Diversion Sub-channel was blocked January 3rd, and the Wanli Paper-Making Plant and a Linhe Liquor Group plant both have been closed. *(1.19.99)*

Beijingers Want Clean Living Areas

Beijing's citizens are becoming increasingly conscious of the cleanliness of their living environment, according to recent survey conducted by the Beijing Mainland Research Company. In what is viewed to be a dramatic change in public opinion from two decades ago, more than 72 percent of the survey's respondents included a "clean environment" among their criteria for an acceptable living area.

China's spectacular economic growth has been accompanied by an increase in pollution, and Beijing - with a rise in vehicle emissions, dust from construction sites, and smoke from burning coal - is now one of the most polluted cities in the world. *(1.26.99)*

SEPA Official Targets Beijing Car Emissions, Coal Burners

The vice-director-general of the State Environmental Protection Administration (SEPA) has called for new measures in the fight against Beijing's air pollution problem. The official, Wang Xinfang, says that new regulations to curb vehicle emissions and to replace coal burners with gas stoves should be in place by October 1, 1999. By 2002, he said, the Chinese capital should meet the Grade II national air quality standard for SO_2 (60 micrograms per cubic meter). *(1.26.99)*

TSR Compliance Emphasized

Twenty percent of China's construction projects do not meet the "Three Simultaneous Requirements" (TSR), says Wang Xinfang, vice-minister of the State Environmental Protection Administration. The TSR, implemented in November, was designed to tackle the enormous amounts of waste and pollution created at construction sites by requiring that treatment facilities be incorporated into each project. Sites failing to meet the TSR requirements will be fined and ordered to cease activities, Wang said. *(1.23.99)*

China Adopts Zero-Growth Fishing Policy

In a move designed to protect marine resources and ensure sustainable fisheries development, China has adopted a "zero-growth" policy for the offshore marine fishing harvest of 1999. The offshore sector's catch in 1998 was 10.1 percent higher on the previous year. China's total aquatic output last year - 39 million tons - represented nearly 40 percent of the worldwide production. *(1.14.99)*

Moving in step with national policy makers, Guangdong province, whose offshore fisheries accounted for nearly 15 percent of China's 1997 offshore output, is targeting a zero-growth rate for its own marine industries. The plan would bar the province's offshore fishing take from exceeding last year's take, and would also eliminate practices such as electrical shocks, poisonings, and explosions. *(2.4.99)*

Funds Allocated for Water Improvements

China's central government will earmark 45 million yuan (US $5.4 million) this year to construct and improve drinking water facilities in those areas seriously hit by last summer's floods. Water problems in those areas are highlighted by the looming specter of possible disease outbreaks which may occur as the weather turns warmer. Until now some places, particularly those in Northeast China and Inner Mongolia, have been spared the post-flood epidemics because of the cold winter weather. But the arrival of spring has health officials on alert, and public access to clean water will be an essential element in disease prevention measures. *(2.8.99)*

Changchun Skies Bluer

Grey snow is a thing of the past in Changchun, where local environmental protection departments report that the city's air quality is at it's best level in 20 years. The amount of suspended air particles in the atmosphere has fallen 0.65 milligrams per cubic meter, to 0.316, following two decades and 16 million yuan (US $2 million) worth of environmental efforts. *(2.10.99)*

Young People Aware of Environmental Issues

A survey by the Chinese Youth Research Centre and Development Foundation finds that young people in China are becoming increasingly concerned about the environment they live in. Of the survey's 6,534 respondents, more than 80 percent said they believe it is very important to protect the environment. *(2.10.99)*

Li Peng Stresses Protecting Environment

In an interview published in Qiushi (Seeking Truth), Li Peng, Chairman of the People's Congress Standing Committee, says that environmental protection is vital for sustaining China's economic growth and social progress, adding that the country's laws must be strengthened to ensure that the country's continued development does not take place at the expense of natural resources and the environment. Li said last summer's floods heightened his awareness of the need for ecological protection. *(2.2.99)*

Regulation Drafted to Protect Wetlands

In an effort to halt ecological deterioration, China has drafted its first law designed to protect its already damaged wetlands. The act, titled the National Regulation on Wetland Conservation, is being drafted and will be submitted to the State Council for approval by the end of 1999. China's wetlands - which are host to 1,540 varieties of plants and 1,500 species of animals, and which play an important role in flood control - have been seriously eroded over the past several decades by exploitation and pollution. *(1.11.99)*

Measures Aim to Reverse Pollution Trends

The Chinese government will implement new measures this year designed to reverse worsening pollution trends. Calling 1999 a "pivotal time" for China's environment, Xie Zhenhua, minister of environmental protection, said that the new laws focus on the rules governing the enforcement of existing environmental regulations, but he added that scientific research and promotion of environmental industries were also priorities. *(1.25.99)*

Plastic Food Containers to be Phased Out

White, polystyrene food containers are to be phased out and replaced by more eco-friendly food boxes, according to the Ministry of Science and Technology, which is expected to increase funding to support the development of "green boxes." China consumes an estimated 10 billion disposable food packages per year, leading to serious "white pollution" in cities, rivers and lakes, and along railway lines throughout the country.

The arrival of the new boxes compliments the country's new regulations limiting the use of foam plastic food containers and forbidding passengers from throwing waste from moving vehicles. Beijing and Tianjin have already begun recycling programs for plastic packages. *(12.14.98)*

Antarctica Team to Report on Global Changes

The findings from China's 15th South Pole Exploration Team will be presented in a report on global atmospheric changes. The group recently returned from a visit to the frozen continent, where they became the first Chinese team to reach the DOM-A area, the highest part of the pole. Ice-core samples collected in DOM-A will provide valuable data about the planet's atmospheric history, thereby assisting researchers in their attempt to predict future climactic developments. *(1.22.99)*

Report Cites Indoor Air Problems

Air quality in Beijing's buildings needs to be improved, according to a report released in December. The report was based on tests conducted by a joint-venture group in four, air-conditioned buildings: a cinema, a restaurant, a four-star hotel, and an office building. The report cited inadequate ventilation and filtration, and insufficient maintenance of air-purification systems as the main factors contributing to the problem. It suggested that the city should develop a set of standards that are in line with international standards for indoor air quality. *(12.21.98)*

Challenges to Environmental Education in the 21st Century

Thomas T. Shen[20]

Introduction

This paper highlights environmental pollution problems; a multimedia pollution prevention (M2P2) strategy; improvement of teaching methodologies; and the role of environmental educators. It calls for a shift of environmental emphasis on education from medium-specific pollution control to multimedia pollution prevention. The purpose is to upgrade the current teaching materials and methods of environmental education that will meet the demand for a balanced economic development and environmental protection

Education is the key to provide us knowledge and skills that are necessary to develop and implement a cost-effective policy, strategy, and program. Environmental education is to prepare a student or working-professional with adequate knowledge and skills so that he/she can contribute his/her learned environmental knowledge and skills to serve in various sectors of our society for a healthy local, regional, national, or global environment and to preserve our natural resources. The challenges to environmental education are numerous, but the focus must be on how to meet the demand of changing social, economic, technical, environmental, and cultural needs. Environmental educators are challenged to examine their educational systems, current curricula and teaching methodologies that must meet the changing needs now and the future. Different countries may upgrade their environmental protection programs differently either because of a conscious strategic choice or because of policy and strategy and competition forcing it to happen. Environmental education programs need to couple with their country's strategic planning process and observe global competition to support its needs. The need for changing may not be the same in every country; however, they do have considerable similarity and mutual influences.

Environmental Pollution Problems

Wastes (gaseous, liquid, and solid), releasing into the environment beyond the assimilation capacity of the environment cause environmental pollution problems. Waste contains pollutants, which are discarded materials or products. All sectors of our society generate waste: industry, government, agriculture, mining, transportation, energy, construction, and consumers. Traditionally, we learned the word "pollution" which focused primarily on control of medium-specific pollutants and wastes from industrial processes as evidenced by our environmental laws, regulations, and management strategies.

With technological advances and changes in life style, the quantity and toxicity of wastes have been increasing. The increase of toxic chemicals and hazardous wastes in our society, cycling in our environment has become man's most urgent environmental pollution problem both now and in the future. Pollution from toxic chemicals and hazardous wastes is more extensive and difficult to manage than originally believed. When toxic chemicals and hazardous wastes contaminate the environment, all life is exposed to the potential high risks. Rapid hazardous pollutant buildups in recently industrialized countries may provide even more persuasive evidence of pollution problems.

Most environmental regulations and enforcement has been media-specific, focusing on violations affecting air or water in specific locations. Pollution control has improved in environmental quality to a certain extent, but in general, it not only fails to eliminate pollutants but also often transfers them from one medium to another. Protection from environmental pollution has also suffered because nearly all actions have been reactive, ad hoc, uncoordinated, and often contradictory. More regulations, higher disposal expenses,

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increased liability costs, and increased public awareness have caused industrial and governmental leaders in developed nations to shift their priority of environmental management strategy from medium-specific pollution control strategy to multimedia pollution prevention strategy; from control technologies to preventive technologies.

Solving environmental pollution problems clearly involves social, economic, ethical, political and legal considerations. Solving pollution problems require not only knowledge, but also an attitude toward uncertainty and innovation. Solving problems can sometimes create problems. For example, in the United States, implementation of the Clean Air Act and Clean Water Act has generated billions of tons of wastewater, sludge, and residue that could cause soil contamination and underground water pollution problems. A legacy of hazardous waste sites presents frustrating challenges for remediation. Non-point sources pollution and hazardous waste disposal sites which represent some of the most intractable problems for restoring and sustaining environmental quality and also cost of billion dollars for cleanups (Shen, 1995).

Multimedia Pollution Prevention (M2P2) Strategy

After many years of environmental protection experiences, we have begun to realize that certain toxic chemicals, products, and environmental unfriendly short-life products can cause even greater pollution in terms of risks to human health and the environment. Waste management practices for major industries have being undergone significant changes. These changes have been driven by environmental regulations; increasing costs of waste management, increasing awareness of pollution problems caused by waste treatment and disposal practices. Knowledge and experiences tell us that we can no longer think simply of clean water or clean air; we must work toward a clean environment. Knowledge and experiences also warn us that waste management will be an uphill battle against environmental problems, unless serious steps are taken to prevent pollution from all sources of waste generation.

Pollution prevention involves not only waste minimization and source reduction, but also cleaner production and unpolluted services. It is the continuous application of a multimedia preventive environmental strategy applied to raw materials, processes, products, and services to conserve natural resources and reduce risks to human and environment. The concept of “pollution management” to complement “waste management” has grown since late 1980s. Pollution management takes a broad preventive approach, looking at industrial product life-cycle pollution problems. This concept prevents not only waste generation from the conventional manufacturing facilities, but also pollution from product distribution, storage, transport and use as well as from products after useful life for disposal. In other words, *waste management focuses on pollutants and wastes, while pollution management deals with not only pollutants and wastes, but also products and services.* Therefore, we need to apply the pollution prevention concept with multimedia approach to manage both wastes and products before they create pollution problems. Unfortunately, many environmental professionals have not realized the concept, practices and benefits of pollution prevention.

Multimedia pollution prevention is one of the most cost-effective and proactive strategies for environmental pollution management because it can:

(1) Reduce risks of environmental quality, human health and ecological damage;
(2) Save money by preventing excessive use of materials, energy, and natural resources as well as generating less wastes for treatment and disposal;
(3) Conserve resources through recycling waste as useful materials in a closed recycling system and reusing wastes and by-products during production;
(4) Reduce pollution resulting from excessive loading of our environment with pollutants and wastes from production, services, and consumption;
(5) Avoid costs of regulatory violations and long-term liability associated with releasing hazardous wastes and toxic products into the environment;

(6) Cut-down construction, operation, and maintenance costs for "end-of-pipe treatment and disposal facilities;

(7) Increase production efficiency and company reputation; and
(8) Avoid environmental unfriendly products and services into market places.

M2P2 asks industries not only if their regulatory obligations and pollution control, but also of promoting environmental awareness in everything they do (USEPA, 1997).

M2P2 strategy is designed to manage environmental pollution from life cycle of products, services, and human behaviors, rather than to manage problems from pollutants and wastes only. Implementation of M2P2 strategy will require (1) a massive resources commitment to M2P2 education and training; (2) a cooperation at all levels and sectors of our society; and (3) a new understanding of preventive concept, full-cost and environment value systems, and innovative management skills. The design and implement of M2P2 strategies for government and industry require well-trained decision-makers and managerial personnel.

Curricula and Methodologies

We are now living in a global economy and our perception has changed and the physical world seems to be getting smaller. The global environment and changing social fabric that is redefining environmental education and learning processes – which traditional teaching and learning methodologies are challenged. The challenges to environmental curriculum and teaching methodology are:

- Broadening environmental courses to various concerned departments
- Increasing interpersonal skills training to deal with a diversified workforce and projects
- Staying close in touch with the needs and forecasts
- Providing life long learning support
- Establishing M2P2 Training Centers
- Strengthening international cooperation and exchange.

As the consequence of technological advances and information explosion, what are the curriculum and teaching methods of environmental education required in meeting the demands of industry and government? Our challenge is how to educate students to be the right professionals, not only form a disciplinary and technical point of view, but also from a personal skill point of view. Today's Internet provides access to a number of basic pollution prevention services via the World Wide Web, electronic mail, information resources, network news, and the ability to transfer files. The Web user can jump from web page to web page by selecting coded links with a mouse or by typing in a web address. The Internet is a powerful tool to search and evaluate information on pollution prevention and technology. It also provides users information on various pollution topics. Several useful websites for pollution prevention information are listed below:

1. The United Nations Environmental Programme (UNEP). (http://www.unep.org/).
2. The U.S. EPA's website (http://www.epa.gov/).
3. The National Pollution Prevention Center for Higher Education (NPPC).
   NPPC's website is (http://www.umich.edu/~nppcpub/resources).
4. The Pollution Prevention Information Clearinghouse (PPIC).
   PPIC's website is (http://www.epa.gov/oppintr/P2home).

Transformation of environmental education is also related to the concerns of quality, productivity and return of investment on environmental education. There is also a question about the effectiveness of the traditional environmental teaching process and methodology. The old style of classroom teaching has stood unchallenged for hundreds of years. But today, the need for rapid curriculum reform and teaching method improvement in environmental education becomes a critical challenge to meet the societal needs. For continuing education, a M2P2 training resource kit needs to be developed to provide trainers and managers

the tools necessary to conduct training courses for governments and companies in their own region. The Kit may include the following modules: Defining environmental policy, multimedia pollution prevention approach, environmental audit, management review, action plan, environmental responsibility, implementation procedures, Internet information, and external communication.

The Role of Environmental Educators

The aim of environmental education is not only to develop knowledge and awareness, but also to encourage problem-solving skills and sensitivity to the link between the development and the environment. Educators must provide the cost-effective science, technology and management skills to students and working professionals. Knowledge with skill is the driving force of human progress. New curricula of a broader environmental policy, strategy, management, implement methodology must be developed and added to the exiting environmental education curricula. Learning and application must involve forging new modes of environmental partnership among industry, business, government and the academic community. New computerized technology for information handling and interactive communications will provide attractive opportunities to make a major contribution.

For the past two decades, we have seen drastic industry transformations that require corresponding changes in environmental education programs, but often colleges and universities are not fast enough in reacting to such changes. Instead of being able to predict of at least observing these changes, educators often wait till public or market pressure forces them to change. Most environmental professionals in government, industry, academia, research institutions and private practice face various types of environmental issues that they never learned about in universities. M2P2 and sustainable development education is a relatively new and fast changing field of study. Thus, continuing education opportunities and specific training must be available to those professional workers who want to learn and understand the principles and practices of M2P2 and sustainable development, as well as to gain science, technology, and management skills for achieving the goal of sustainable development. In recent years, through various workshops and seminars, professionals and students realize the need to expand their knowledge from pollution control to pollution prevention as well as from scientific and technical aspects to socioeconomic and cultural aspects.

Challenges to environmental education rely heavily on educators' way of thinking and action on environmental management strategies. Educators must cultivate an understanding of the critical environmental issues and problems, especially the risks and potential impact of toxic chemicals and hazardous wastes associated with our daily decisions. One of the key challenges is to learn the concept and practices of M2P2. Training of decision-makers at all levels will be helpful in formulation and implementation of new policies and programs. Topics such as M2P2, environmental management system (EMS), product life-cycle analyses (PLCA), total cost analyses (TCA), partnership approach and others are very important to achieve the goal of sustainable development. Educators need to search for adequate, reliable data and information. No management tool is more powerful than data and information. M2P2 decisions must have access to make use of data and information that enables them to consider and implement M2P2 program actions. Academic researchers are challenged to compile and analyze the collected data, and then disseminate the summarized results of environmental, economic technical, and social information to decision makers at the individual, corporate and institutional levels.

Fortunately, the computer age in which we live allows us to manipulate, integrate, analyze, and visualize information to knowledge in new way. Computer technology has resulted in global markets for the exchange of knowledge, information, goods, and services, because of telecommunication technology, which transfers information and knowledge quickly and accurately worldwide. These computer and telecommunication technologies certainly play a vital role for educators in creating new environmental materials and teaching methodology required for modern education and training (NPPC 1998).

Continuing education is an important part of education. Educators need to help develop government-industry-consumer partnerships with creative solutions. The desired societal perception of environmental educators and future professionals are:

- Learning to cope with technical advances
- Practical, real-world experiences
- Broadly based views in sustainable development
- Engineering team concept and partnership approach
- Integration to completion.

Conclusions

Sustainable development is our goal and multimedia pollution prevention (M2P2) is our tool to achieve that goal. Environmental educators are challenged to teach a balance between technological advancement and resources preservation, as well as a balance between industrial development and environmental protection. The challenge is to develop and implement M2P2 teaching materials and methodology that will educate and train students and working-professionals, to learn beyond waste management strategies to pollution management strategies, and to think not only at present, but also in the future.

Education and training can take many forms to provide knowledge for students and working professionals as well. Environmental education needs new curriculum materials, new courses, new degrees in universities, new corporate practices, new legislation, and new Cyberspace Assisted Responsive Education. We must deal with the underlying causes of pollution problems, not the symptom only. Effective public education is also essential to environmental education programs.

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Field Notes – Abstracts from recent research

Energy Efficiency and Climate Impacts of Foreign Direct Investment in China's Power Sector[21]

Allen Blackman and Xun Wu

In the next thirty years, developing countries will become the leading source of greenhouse gas emissions thought to cause global warming. Yet countries where weak public sectors and widespread poverty are pressing concerns are unlikely to be willing or able to undertake costly measures to lower emissions. Energy efficiency improvements may help resolve the dilemma. They not only reduce emissions of greenhouse gases but in some cases also significantly cut operating costs. Conceivably, firms in developing countries could be induced to invest in energy efficiency of their own accord or with minimal prodding. Foreign direct investment (FDI) by multinational corporations may be a principal means of transferring both the technology and the financial capital needed for such investments.

The Chinese electricity generating sector is an important test case for this hypothesis. China is already the world's third leading source of greenhouse gases and is likely to become the biggest contributor before the middle of the next century. China's fast-growing, almost exclusively coal-fired power sector is responsible for roughly a third of these emissions. In the early 1990s, China opened its doors to foreign direct investment in the power sector, a development that was met with a wave of enthusiasm by multinational corporations. What impacts has this recent opening had thus far?

Data from an original survey of twenty American wholly-owned or joint-venture power plants in China suggest that FDI is indeed having a significant positive impact on energy efficiency. Average rates of coal consumption per kilowatt hour of electricity generated for the plants surveyed are considerably lower than those for new Chinese plants of similar scale, and are even lower than those for new American plants. The main reason is that almost a third of the twenty plants use state-of-the-art generating technologies such as combined-cycle gas turbines (CCGTs) and circulating fluidized bed (CFB) boilers. These technologies have characteristics that make them especially attractive in China. Both CCGTs and CFBs accommodate the use of relatively cheap and plentiful low-grade fuels, a valuable feature given that the quantity and quality of fuel supply in China is uncertain.

In addition, unlike conventional steam turbines, CCGTs can be run efficiently even when start-up and shut-down on short notice is as often required in China. The plants in the RFF sample are even more efficient than rates of coal consumption indicate: a fifth of them use "waste" heat to generate heat or steam for industrial or residential facilities.

But not all the characteristics of FDI in China's power sector are encouraging from the standpoint of energy efficiency. To avoid the lengthy central government approval process for large plants and to minimize risk, early FDI tended to be in small-scale plants generally not as energy-efficient as large-scale plants. Perhaps more important, data from trade journals indicate that despite investors' early enthusiasm, the volume of FDI in China's power sector will likely fall short of government targets for the year 2000 by a substantial margin. In large part, this short-fall is the result of persistent institutional barriers to FDI. Survey data suggest that the most important barriers are the uncertainties associated with the approval process for FDI projects, the regulation of the electricity sector, and the risk of default on power purchase contracts.

[21] This article, previously published in Resources for the Future's quarterly "Resources," is drawn from "Foreign Direct Investment in China's Power Sector: Trends, Benefits and Barriers." Resources for the Future Discussion Paper 98-50 by Allen Blackman and Xun Wu. The paper is available in PDF format at www.rff.org.

PACE Workshops: Recent and Upcoming

2nd Environmental Policy Forum in Beijing

On November 10-11, 1998, PACE co-organized a workshop of China's Environmental Policy Perspectives in the 21st Century, jointly with China State Environmental Protection Administration (SEPA)'s Policy Research Center.

SEPA's Administrator Mr. Xie Zhenhua, a number of other SEPA officials, and about 20 scholars participated in the workshop. Minister Xie briefed the workshop participants on China's current practices in environmental protection and answered questions from the participants. Fifteen papers were collected and twelve presentations were made during the workshop. WWF-China offered financial support.

Changhua Wu, PACE's Vice President, chaired the one-day-and-a-half discussion. Zhang Kun, Director of Sino-Japanese Environmental Protection Center, Cao Fengzhong, Director of SEPA Policy Research Center, and Hua Wang, PACE's President, spoke at the opening ceremony. PACE Chairman Jian Xie, PACE Director Ray Phillips, PACE Beijing Office Coordinator Jinnan Wang and several other PACE members also participated in the workshop.

Brown Bag Seminar on Development of China's Environmental Legislation

When it comes to China's environmental legislation, Dr, Zhang Hongjun, a distinguished and young legislative worker in China, has two points to share with you: 1) be confident; and 2) be patient.

The Deputy Director of the Legislative Office of the Environmental Protection and Resources Conservation Committee of China's National People's Congress, Dr. Zhang has been an active player and insider of the recent development of China's legislative process. He gave a presentation on February 10, hosted by PACE and the World Bank's East Asia Environment Department, in Washington, DC, on:

1) the new development of environmental legislation and policy in the last five years;
2) the environmental legislative plan of China's congress in the next five years;
3) the policy direction on the environment protection and resources conservation; and
4) some on-going issues concerned by researchers and practitioners within and outside China, such as climate change, sustainable development, air pollution control in Beijing, and Lake Tai treatment. (More detailed analysis on China's environmental legislation can be obtained from the articles carried by this journal written by Dr. Zhang and Richard Ferris.)

Dr. Zhang obtained SJD in Environmental Law from Peking University. With ten years of experiences working at SEPA and the Environmental Committee, Dr. Zhang is a leading member at China's National People's Congress in drafting and revising a number of major environmental laws, including the Air Pollution Prevention and Control Law, the Water Pollution Prevention and Control Law, the Solid Waste Prevention and Control Law, the Noise Pollution Prevention and Control Law, the Land Administration Law, and the Marine Environmental Protection Law.

Tsinghua University to Become the First Green University in China

China is determined to green its universities. And Tsinghua University is the leader. By focusing on green education, green science and technology, and green campus, the University is on its way towards the goal, according to Dr. Hao Jiming, Dean of the School of Environmental Engineering of Tsinghua University.

Hosted by World Resources Institute (WRI), Professional Association for China's Environment (PACE), and the World Bank's East Asia Environment and Social Sector, Dr. Hao gave a one-hour seminar in Washington, DC, on February 23.

The Ministry of Education, Ministry of Science and Technology, and State Environmental Protection Administration have approved the Green University project of the University. Divided into two phases, the demonstration, first started last June, will complete its first phase in 2001 and its second phase in the year 2006. By then it is expected that other universities will follow suits.

The Green University is using environmental protection and sustainable development as its guiding principles. Specific programs include that all undergraduate students have to take at least one course on environmental science; the university provides elective courses for graduate students, as well as Ph.D. students. A special course – Introduction to Sustainable Development – is open to Ph.D. students. "All graduates from Tsinghua University are expected to possess the abilities of assessing and dealing with issues related to sustainable development and environmental protection," said Dr. Hao.

Green Science and Technology emphasizes the environmental impact assessment of all research projects. And Green Campus includes four major green belts, four large lawns, 10 courtyards, and 10 small gardens. The emphasis will also be made to control current pollution on campus, including promotion of non-smoking on campus.

Creating Incentives for Industrial Firms to Control Pollution in China

Co-sponsored by:
Professional Association for China's Environment (PACE)
China State Environmental Protection Administration's (SEPA) Policy Research Center
World Bank's Development Research Group

Date: 17-18 May 1999

Location: SEPA's Policy Research Center
#1, South Yuhui Road,Chaoyang District
Beijing, China

Invitation to Submit Abstracts
In order to create incentives for pollution control, government must have in place strong programs to monitor the behavior of polluters and enforce compliance with the desired environmental performance. It has been recognized that monitoring and enforcement practices have generally been too weak to create strong incentives for pollution control in China. On the other hand, recent experience and research has shown the powerful roles of public information, public participation, etc. in exerting pressure on polluters through local communities, markets (both consumer and capital markets) as well as courts.

The purpose of this international workshop is to discuss and share expertise on governmental monitoring and enforcement issues pertaining to China, and to assess the potential role of non-governmental means such as communities and markets in the rapidly evolving context of China. For those who wish to present at the

workshop, paper abstracts (of no longer than 2 pages) are cordially invited. Papers will be selected as a function of their clear focus on providing incentives for industry to control pollution.

Abstracts should be submitted by March 16 to Ms. Ping Yun at email:
pyun@worldbank.org, or fax: 202-522-3230. Authors of selected papers will be advised of their selection by March 30. Completed papers are due by May 1, 1999. For those who are located in China, abstracts can also be sent to Ms.Guomei Zhou of SEPA's Policy Research Center at email: zhoug@bj.col.com.cn or Fax: 6492-4241, Beijing.

Costs:
All participants are expected to cover their own costs. Registration is free for PACE members, SEPA and World Bank staff; all others, $30 each to cover meals and materials.

Contacts:
For registration and logistics, please contact Ms. Guomei Zhou of SEPA's Policy Research Center, Beijing (Email: zhoug@bj.col.com.cn; Tel: 6492-4241; Fax: 6492-4241). For presentation and round table discussion, please contact Ms. Ping Yun of World Bank's Development Research Group, Washington, DC (Email: pyun@worldbank.org; Tel: 202-458-7140; Fax: 202-522-3230).

Conference Corner

Sino-US Energy Development Conference
Date: 26-28 April 1999
Location: Key Bridge Marriott, Arlington, VA, USA
Sponsored by: Honeywell, International Resources Group, Ltd., EPRI, and KNL.

For more information, contact Brent Lancaster of EPRI at (704)547-6017 or *blancast@epri.com*
Or visit http://www.htc.honeywell.com/energyconf

Call for Contributions

To ensure the quality of SINOSPHERE, the editorial staff needs contributions from you, our members. We hope to establish a backlog of pertinent articles that we can draw on from time to time over the next few months, but our success ultimately depends on your willingness to provide us with information. In general, we need three types of contributions:

Abstracts

If you have written, published, or presented any articles that are relevant to the study of China's environment, please send us an abstract of the article and information on how we can obtain a copy (Publication date and location, or personal address). We would like to include these abstracts in our upcoming issues to inform our readers of the type of research that is being carried out by PACE members and to stimulate discussion about environmental issues.

Articles

For those of you interested in specific issues, we would like you to express your views in short scholarly essays devoted to a single topic. We welcome articles on any subject, including technological developments, business trends, and policy issues. These articles should be approximately 2000 words in length, although quality is more important than quantity.

Autobiographical Sketches

Please send us brief descriptions of your educational background, current occupation, research interests, and any specialized information regarding your involvement in issues related to China's environment. You should also include a current address and a contact number. (100-200 words)

Remember that SINOSPHERE will be read by more than 500 people worldwide, many of whom have influential positions in the public and private sectors, academia, and NGOs. This is your chance to communicate with like-minded individuals who share your interest in China's environment and to tell them of your research and concerns.

Please send all submissions to the editors at ctsao@umich.edu