Climate Change Mitigation: Case Studies from China

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CLIMATE CHANGE MITIGATION: CASE STUDIES FROM CHINA

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Foreword

The Advanced International Studies Unit (AISU) of Battelle, Pacific Northwest National Laboratory developed a series of case studies to document an important trend: the emergence of cost-effective carbon mitigation opportunities in transition economies. The following report focuses on selected cases that describe innovative Chinese approaches to mitigation. This research captures the essence of AISU's approach to environmental problem-solving. First, the case studies address an applied, global policy issue. They also focus on policy tools that enhance economic well-being. Finally, the studies provide first-hand analysis from experts in the host country.

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Introduction[1]

As a developing country party to the Framework Convention on Climate Change (FCCC), China is not yet obligated to meet specific greenhouse gas (GHG) emission targets. Currently, no Chinese projects or programs exist that are designated as GHG mitigation programs. Several projects sponsored by the Global Environmental Facility (GEF), however, are related to GHG mitigation. Early GEF projects focused mainly on policy studies, but projects currently under development are more applied and include a coalbed methane study, a boiler efficiency improvement project, and an effort to introduce new energy conservation mechanisms into China.

Many studies and analyses of climate change have also been carried out by Chinese institutions or in cooperation with foreign institutions. These studies identify technical and economic measures and options for emission mitigation. The most important GHG mitigation measures in China include the improvement of energy efficiency, the substitution of gas for coal, the expansion of the nuclear power sector, and the development of renewable energy. Another important conclusion from the case studies is that many different mitigation measures and options are necessary to put China on the path to sustainable development.

The Chinese government has adopted sustainable development as its basic policy for social and economic development. Environmental protection has been given greater and greater importance. The government has sponsored a series of programs to encourage energy conservation and promote the use of renewable energy. Since the early 1980s, the government has developed national energy conservation plans for each Five-Year Plan. These plans specify energy conservation targets for each economic sector and province. Governmental agencies and national investment companies allocate funds to energy conservation projects. The government also sponsors public education and information dissemination activities. For example, each year a nationwide, week-long energy conservation campaign is held to disseminate knowledge on the benefits of energy conservation.

As a result of these efforts, China has lowered the income elasticity of its energy consumption from more than 1.5 during the 1950 to 1980 period to less than 0.6 in the

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1980s, and less than 0.4 over the last six years.[2] Meanwhile, the government has also sponsored many programs to promote the development of renewable energy. While these programs are not designed specifically to mitigate climate change, they have reduced GHG emissions significantly. The programs provide economic and environmental benefits that make the projects entirely justified on their own, and they comprise a "no regrets" approach to mitigation.

This paper describes three representative activities in energy conservation and renewable energy that are currently mitigating GHG emissions. Their effects and performance may be important as demonstration examples if mitigation programs are carried out in China in the future.

[2] Income elasticity of energy demand equals the percentage change in energy demand divided by the percentage change in income.

Case Study 1:
China Green Lights Program

Background

The China Green Lights Program (CGLP) is an energy conservation program initiated and implemented by the Chinese government. From a climate standpoint, it can also be considered a GHG emissions reduction activity.

Energy shortages, particularly electricity shortages, used to be a major constraint to economic development in China. In the 1980s, mandatory electricity blackouts were common in many areas of the country's electricity grids to prevent generation systems from overloading. The electric power sector has the highest growth rate among all of China's energy industries. More than 15 GW of new capacity has been installed annually over the past five years. Current forecasts call for similar or higher additions in the future. Although electricity shortages in many places have eased, peak load demand has yet to be satisfied. Meanwhile, the cost of newly installed generators has risen. About 80 percent of China's power is generated by thermal power plants and fueled primarily with coal. Saving electricity is, therefore, one of the most important national policies for energy conservation and environmental protection.

In 1995, total electricity consumption reached 1,000 TWh in China. Lighting accounted for more than 10 percent of this amount, and most electricity consumed by lighting occurred during peak load periods. The proportion of electricity used in lighting is projected to increase in the near future. The Chinese government has considered electricity conservation in lighting as an important means of energy saving since 1992. The government convened experts to carry out studies on the necessity and feasibility of implementing the CGLP. This program will provide three benefits: energy savings, peak load shortage alleviation, and environmental protection.

More than 1,000 plants in China currently manufacture lighting products such as bulbs and lamps. China also produces a great variety of lighting products. In 1994, Chinese plants produced approximately 2.4 billion incandescent bulbs, 300 million fluorescent bulbs, 1.2 billion lamps, and 80 million compact flourescent lamps (CFLs). About 80 percent of the CFLs made in China in that year were exported. The quality of high-voltage sodium lamps and metal halide lamps made in China is competitive in the international market. The quality of most of the domestic CFLs, however, is lower than that of CFLs produced by popular foreign companies. The domestic lighting market is still dominated by old, inefficient products. The market share of high-efficiency lighting products is very small compared to the huge number of old incandescent bulbs. The majority of fluorescent bulbs are still inefficient, large-diameter T12 tube bulbs. Magnetic ballasts are much more popular than the efficient electronic variety.

Experts have identified several barriers hindering the market penetration of high-efficiency lighting. The low quality of many high-efficiency lights is a major barrier. For example, one study found that one third of CFLs failed in residential applications within 7 months of purchase. Lamp life averaged less than 1,000 hours in the demonstration city studied. These problems are also common in other cities. Many users believe that CFLs can save energy, but not money.

Another barrier is the higher initial cost of high-efficiency lights. For example, a domestically manufactured CFL is priced at 26 Yuan ($3) or higher; a GE or Phillips CFL costs 70 to 100 Yuan ($8.50 to $12). Domestic incandescent bulbs, on the other hand, cost only about 1.5 Yuan ($0.20), while the imported GE or Phillips versions cost less than 10 Yuan ($1.20). In addition, most plants producing high-efficiency lights are small and have a low level of automation. As a result, product quality suffers and prices remain high compared to traditional units. Investment for automation is hard to obtain under current circumstances. These barriers cannot be overcome in the near term given the existing market situation in China. A program to promote high-efficiency lighting is thus necessary.

Institutional Structure

The idea for a "green lights" project was borrowed from the United States and other developed countries. The green lighting programs in these countries are successful in saving energy. After initiating careful preparation and market surveys, the Chinese government established the CGLP in 1996.

The CGLP has been identified as one of the key national energy conservation programs during the ninth Five-Year Plan period (1996 to 2000). The State Economic and Trade Commission (SETC) manages the program. The SETC is in charge of technology retrofit and replacement including energy conservation projects in China. The SETC assembled a Lead Team to coordinate the program, with representatives from the State Planning Commission (SPC), the State Science and Technology Commission (SSTC), the Ministry of Electric Power Industry, the Ministry of Construction, the Ministry of Electronic Industry, the Ministry of Agriculture, the China National Council of Light Industry, the Chinese Academy of Sciences, and its own organization. The vice chairman of the SETC, Mr. Shi Wanpeng, chairs the Lead Team. This group is in charge of coordinating all relevant government agencies involved in the program, providing policy guidance, approving work plans, and supervising the CGLP program office.

Project organizers established a program office under the Lead Team that is headed by officials from the SETC. This office develops work plans for the CGLP in both the Five-Year Plan and the annual plans. The program office is also in charge of day-to-day operations. The Beijing Energy Efficiency Center (BECon) is the program office's major source of technical support.

The CGLP also assembled a group of 17 experts on energy conservation, lighting technology, and science. This expert team provides technical advice to the program and helps to develop working plans. More experts will be invited to join the program as needed.

The program office also established several working groups to organize and accomplish specific tasks. For example, the information dissemination and education work groups are responsible for developing materials on high-efficiency lighting and publicizing the CGLP through press briefings, printed materials, TV programs, magazine articles, conferences, and workshops. The program office also established a working group to develop standards and codes for lighting products. Another working group will organize demonstration and pilot projects and select recipients of SETC grants or loans for improving technology or expanding production capacity. The working groups are composed of officials from relevant government agencies and research institutions. Individual consultants have also been invited to join the working groups.

The CGLP is a national program initiated by the central government, which has asked all provincial governments to participate. As a result, many activities have been initiated by local governments according to their particular conditions.

Lighting manufacturers are important members of the program. Policies are being developed to encourage manufacturers to contribute to the program, including standards and codes, pilot projects, and recommendations for improving lighting quality. Program organizers are considering forming a voluntary committee composed of manufacturing representatives to develop proposals for the CGLP.

Objectives

The CGLP has several objectives. The direct objective is to increase the number of high-efficiency lights in use to 300 million units per year by 2000 (200 million CFLs and 100 million thin-tube fluorescent T8 and T5 lights). Nationwide, the project is expected to save 22 TWh of electricity each year by 2000. These savings translate to approximately 26.8 TWh of electricity that will be reduced from baseline demand. These savings will equal 7.2 GW of peak load generation capacity, because most lights are used during the peak load period. Associated energy savings from efficient lights could reach 13 million tons of coal annually by 2000, and will increase thereafter. Financial benefits are estimated at 30 to 40 billion Yuan ($3.6 to $4.8 billion) because more than 9 GW of planned power supply will be avoided. Environmental benefits are also great: about 200 thousand tons of sulfur and 7.4 million tons of carbon emissions will be avoided annually by 2000.

Another objective of the CGLP is to speed up the development of high efficiency light production. The CGLP plans to increase the production capacity of CFLs from the current level of 80 million bulbs per year to 300 million bulbs by 2000. Advanced thin tube fluorescent lights will also be introduced into China. Metal halide and high-voltage sodium lamps have been recommended to replace low-efficiency mercury vapor lights. The CGLP development plan also includes high efficiency ballasts and other lighting components. The Chinese government recognizes that this target is ambitious and can be achieved only if market forces are in operation.

The CGLP is encouraging market forces by developing a market for green lights. Fluorescent lights account for less than 10 percent of the lighting market, and many barriers have prevented high-efficiency lighting from achieving a larger market share. The government will raise public awareness of the conservation potential of green lights and encourage fair competition in the lighting market, sending the appropriate signals to users and manufacturers. If consumers are willing to buy green lights, producers will develop the industry by themselves, bringing capital and other resources to the field.

One particularly important CGLP objective is to improve the quality control mechanism and management system for the high-efficiency lighting industry, both for product quality and after-sale service. The quality of after-sale service is very important to Chinese consumers. High-quality efficient lighting products are critical to developing China's green lights industry. The technical characteristics of the products (efficiency and lifetime) and their cost competitiveness will determine the industry’s future.

Another CGLP objective is to help Chinese policy-makers learn to operate in a market environment. CGLP will develop and implement new, market-based approaches and measures for policy-makers. Government agencies will no longer be able to rely upon the direct allocation of resources by administrative order; consumers and enterprises will become the major players in the program.

Main Elements

Although the specific CGLP objectives focus on conserving energy and improving lighting service to consumers, CGLP is also a complex social engineering program. The program will achieve its targets by mobilizing potential contributors. Clear market signals and supplementary nonmarket instruments will be combined to promote consumer demand and producer response. Government grants and loans will act as seed money to attract greater social resources in developing efficient lighting products, and the government will help participants to address market failures or imperfections.

Element 1: Information and Education.

Public education will focus on the significance of green lights; not only on the effect of energy saving and/or environmental protection, but also on the economic benefits for users and producers. Public education will also disseminate information on how the CGLP can help achieve these benefits through high-quality and low-cost efficient lighting products. This element is absolutely essential if the program is to achieve its goals.

Element 2: Improving Policy and Regulation

- *Developing and improving standards and codes.* Standards and codes are important policy measures to help manufacturers improve the quality of their products. Standards and codes can help users judge if the lighting product is of high quality. An adequate standards and codes system can help maintain manufacturers' efforts to improve their products. It can also help to eliminate low-quality lamps from the market.

- *Encouraging the implementation of the CGLP*. Incentives and mandates shall be developed to promote the use of green lights.

- *Introducing new financial mechanisms for green lights*.

Element 3: Developing the Market for High-Efficiency Lighting

This component will establish a high-quality production system, introduce a quality inspection system, and phase out low-quality products in order to expand the market share of high-efficiency lighting.

Element 4: Financing for Technology Development and Capacity Expansion

The government will provide grants and low-interest loans to help develop the green lights industry. The CGLP program office will identify leading manufacturers of high-quality lighting products. Special loans will help these manufacturers expand production capacity to achieve economies of scale and improve quality. Approximately 500 million ($60 million) in government loans will be provided in the ninth Five-Year Plan period.

Element 5: Demonstrating and Popularizing Efficient Lighting

Two types pilot projects exist: green light utilization demonstration projects and manufacturing improvement projects. Demonstration projects will convince consumers of the technical and economic performance of efficient lighting and provide suppliers with data on consumer preferences. Supply improvements will demonstrate how new technologies, processes, and equipment can improve quality and decrease cost.

Element 6: Enhancing International Cooperation

The CGLP will introduce successful experiences from other into China. Foreign manufacturers of high-efficiency lights have been invited to introduce new technology and products from abroad as a part of the CGLP. International financial assistance is also welcome.

Results to Date

Although the program has been underway formally for only one year, progress has been significant. Some of the CGLP's achievements are listed below.

1. *Government-Approved Project Work Plan:* The CGLP work plan was printed and distributed to all governmental agencies, local governments, and major lighting manufacturers. Several ministries and provincial governments established special green lights offices and developed work plans reflecting local conditions.

2. *Education and information dissemination projects:* The CGLP was the main topic of China's 1996 Energy Conservation Week. The CGLP held a press briefing and appeared in special television and radio programs. Many newspaper articles were written to increase public knowledge about efficient lighting, and 30,000 CGLP brochures were printed.

The CGLP established a Beijing Exhibition Center in October 1996. Over 75 manufacturers from 18 provinces display their products in the exhibition center. The center is a permanent facility designed to spread the word about efficient lighting products. More than 800 groups have visited the center. Many workshops for manufacturers have been held in the center, including a workshop to introduce standards for high-efficiency lights and a training course on quality inspection methods. More than 10 million Yuan ($1.2 million) has been spent on high-efficiency lighting products since the exhibition center opened.

The International Symposium for Green Lights in China was held in 1996. More than 140 participants from 20 governmental agencies and many research institutes and manufacturing centers attended the symposium. The SETC co-sponsored the symposium with Philips, Osram, Matsushita, Toshiba, and Motorola. Green lights activities in the United States, Japan, Germany, and Southeast Asian countries were described at the symposium. The meeting also summarized the main developments in green lighting technology and products.

The CGLP Office has signed an agreement with Motorola to co-sponsor the 1997 International Symposium for Green Lights in China. Other co-sponsors are likely. This symposium will focus on the policy, technical, and marketing issues surrounding high-efficiency ballasts. It will be a featured event of China's 1997 Energy Conservation Week.

3. *Pilot Projects for Green Lights:* Pilot projects to encourage the use of efficient lighting products have been carried out in cities and regions all over China. Large-scale projects to popularize green lights were carried out in Shanghai, Guangdong, Shandong, Zhejiang, Hunan, Shanxi, Shaanxi, Sichuan, and other provinces. In 1996, more than 10 million CFLs were sold in Shandong Province due to promotional efforts. High-efficiency lights in Shandong alone accounted for a reduction of 300 MW of peak load demand and 400 GWh of electricity consumption. More than 4 million CFLs were sold in the city of Weifang (a demonstration site in Shandong Province), reducing peak load power demand by 100 MW and saving 189 GWh of electricity. High-efficiency lighting also improved the voltage stability and quality of power on the grid by easing power shortages. In the first half of 1995, Weifang's power was cut off 2,000 times as a result of power shortages. In 1996, power outages were reduced to 234 because of the green lights program in the city.

The CGLP Office recently sent an investigation team to evaluate the project in Weifang. Based on a sampling survey of 800 households, hundreds of commercial users, and all local utility distributors, the results of the green light programs in the city are very encouraging. Almost all commercial users gave high marks to the economic performance of the new lights, and they confirmed saving money on their electricity bills by using CFLs and other high-efficiency lights. In households, the story was more complicated. Many residents commented that the new lights lowered their electricity bill, but not significantly. The investigation found that in most households, users improved the quality of light in their homes because the high-efficiency lights provided more lumens at a lower power consumption level. The users, however, did not usually make an equal substitution when changing bulbs. For example, many users replaced 25- or 40-watt incandescent bulbs with 11- or 18- watt CFL bulbs with the lumen power of 60- and 100- watt incandescent bulbs, respectively. All of the distributors made positive comments on the green lights and verified the peak load decrease and electricity savings. Unfortunately, the quality of the lights used in the Weifang project (all were domestic makes) was much lower than what participants expected. Although the manufacturer involved in the project promised to replace all bulbs that failed during their first year of service, consumers were still not satisfied.

The CGLP also created a greater role for utility demand-side management (DSM) projects in China. The DSM concept was introduced into China to lower electricity shortages and improve the quality of power supplies. The Ministry of Electric Power (MEP) encourages utilities to apply DSM as an approach to saving electricity. Participation in the CGLP has since become the most popular DSM project that many utilities offer to their customers.

Similar projects have been sponsored in the railway sector and building construction sector. The Chinese railway system has identified high-efficiency lighting as a key measure for saving energy in the railway sector. The Ministry of Urban and Rural Construction has initiated pilot projects to popularize high-efficiency lights in both the design and construction of apartment buildings.

4. *Policy and Standards Development for Green Lights:* This component includes developing standards and codes that will encourage the use of green lights and facilitate their improvement. China's first two national standards for CFLs and fluorescent tubes have been developed under the CGLP and issued by the State Technology Supervision Bureau, which is in charge of all national standards. Additional standards will be developed for adapters and sockets for high-efficiency CFLs and metal halide lamps. These standards help manufacturers to improve quality and provide users with the information they need to make informed purchasing decisions.

CGLP is currently developing regulations that will add or modify codes for lighting design in residential and commercial buildings. Program organizers are also discussing a regulation that would require all public buildings to improve their energy efficiency with high-efficiency lights.

The CGLP program office is carrying out a nationwide project to recommend the first set of efficient lighting products that feature high quality and good service. This project will advertise the top ten high-efficiency lighting products and encourage competition among manufacturers. The quality of lighting products and services will determine the program's success. The CGLP will publish the names of top manufacturers, providing consumers with information on which products are most reliable. A labeling program will follow.

Economic Assessment

At this stage, it is impossible to assess the total economic effect of the CGLP. Based on sample surveys of pilot projects, however, commercial buildings using high-efficiency lighting achieved savings in both energy and money. The cost-benefit analysis for projects varies according to the service hours per day and the luminary requirements. Green lights are an effective measure for electricity conservation. In China, electricity savings can reduce carbon emissions significantly because coal is the dominant fuel in the power generation sector.

Program Financing

The United Nations Development Program approved a $995,000 grant to CGLP to support several activities, international technical tours, training, workshops, information dissemination, education, and the use of foreign consultants.

The Chinese government provides comparable funds to support the program at the national level. About 500 million Yuan ($60 million) is available in the form of loans with favorable interest rates for improving and expanding production facilities. Local governments and utilities are providing additional financial support. In some provinces, utilities have provided millions of Yuan to sponsor green lights programs as DSM projects. The China Energy Conservation Investment Corporation added 30 million Yuan ($3.6 million) to establish the Huaming lighting company, a coalition of green light manufacturers. The sales revenue from high-efficiency lighting products in China has already reached several billion Yuan per year and is increasing rapidly.

Case Study 2: New Mechanisms to Promote Energy Conservation in China

Background

China has made remarkable energy efficiency improvements over the past 15 years. Energy intensity, a measure of energy consumption per unit of economic output, declined from more than 1.0 in 1980 to 0.5 by 1994. Annual efficiency improvement averaged 4.2 percent over the same period.[3] During the first six years of this decade, the elasticity coefficient of energy consumption dropped below 0.5, while average annual growth in China's gross domestic product (GDP) exceeded 10 percent. Energy efficiency improved by over 5 percent per year on average during this period. This improvement rate is unprecedented among developing countries, where energy intensity is usually greater than 1.

Throughout the 1980s, the government played a dominant role in China's energy efficiency improvements. The government achieved these improvements by controlling both energy supplies and funds and/or grants used to implement energy conservation projects. Energy combustion quotas were allocated by the government to limit energy consumption among users. Energy supply stocks still could not keep up with the rapidly growing demand that followed economic reform.

Economic reform brought changes to the country's energy sector. First, coal supplies expanded rapidly, driven by growth from outside the government's central plan. Second, electricity growth was high, almost matching the overall rate of economic growth. Third, increased demand for oil led to rapid growth in petroleum imports. Energy shortages were reduced in many places, although new imbalances occurred periodically. As a result of these changes, energy conservation policies that worked well under central planning were no longer very effective. Quotas remained a powerful tool for maintaining some control over consumption, but the many new consumers who purchased energy on the open market were beyond government control.

Fortunately, energy price reform has progressed solidly over the last 10 years. Coal prices are now determined by the market, and oil prices have reached international levels. In coastal regions of China, electricity tariffs are as high as those in developed countries.

Energy analysts have puzzled over why energy efficiency continues to improve. Analysis shows that the energy intensity improvement in industrial processes is far lower than that of the intensity by added value. Some studies have determined that 30 percent of the

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[3]For comparison, the corresponding figure for the same period in the United States was about 1 percent.

increase in energy efficiency has been due to technology improvement, with the remainder due to structural change. The question remains whether this structural change is the result of specific energy conservation policies. Furthermore, investment in government-approved energy conservation projects is only a small percentage of total capital investment, and overall capital investment is increasing much faster than investment in energy conservation projects.

Energy efficiency in China remains very low compared with levels in developed countries. Even when purchasing power parity is used as a basis for comparison, China's energy intensity is still two or three times higher than most industrialized nations. In production processes, energy consumption per unit in China is significantly higher. Many domestic surveys indicate that energy technology innovation is progressing slowly in China. Although great potential exists for energy efficiency improvements, this potential is difficult to realize because of market failures.

Although measures to promote energy efficiency based on central planning are increasingly less effective, China's energy market also does not work well in many cases because of barriers and market failure. Introducing new mechanisms to promote energy efficiency is thus a new challenge for China.

Introduction to the ECPP

The Energy Conservation Promotion Project (ECPP) was developed by the Chinese government to foster energy efficiency in China's changing economic conditions. The old system consisted of various conservation-oriented institutions at the central, provincial, and municipal government level, as well as in each ministry and industrial sector. These institutions included energy conservation offices, energy conservation centers, energy efficiency monitoring centers, and energy efficiency information and service centers. With the conversion of China's economic system to a market economy, however, this system must be modified. Old institutions must evolve, survive, and develop while saving energy in a changing economic environment. Most of these institutions need to develop new strategies and build new capacity in the field of energy conservation.

The Chinese government recognizes the need to adapt its energy conservation infrastructure to maximize the role of market forces, and it strongly supports the development of market-oriented initiatives. Enterprises now adopt energy efficiency measures as a means of increasing profits and/or complying with environmental regulations. New and different financing approaches and mechanisms are necessary, and promotional activities must address the enterprises' self-interest. Support for the introduction of market-oriented approaches is especially important at this stage.

Chinese governmental agencies, represented by the SETC, are cooperating with the GEF and the World Bank to introduce energy service companies (ESCOs) into China. ESCOs finance equipment upgrades in host enterprises by agreeing to share a portion of the savings in monthly energy bills. After a fixed period, ownership of the equipment transfers from ESCO to host, and the host retains all future savings. The project will institute an improved national information program for all types of energy conservation projects. It will also develop energy performance contracting in China to circumvent perceived risks, economic problems of scale, high transaction costs, and enterprise financing constraints.

Objectives

The primary objective of the ECPP is to achieve sustained increases in energy efficiency, reduce GHG emissions growth rates, and reduce other pollutants. This objective will be met by introducing, demonstrating, and disseminating new project finance concepts and market-oriented institutions that will promote and implement energy efficiency measures. The first phase of the project will support the establishment, pilot testing, and commercial demonstration of three ESCOs. The ESCOs, which are referred to as energy management companies (EMCs) in the Chinese project, will be located in Beijing, Liaoning, and Shandong. The experience with energy performance contracting gained from the pilot EMCs will then be replicated on a much larger scale throughout the country. The project will also establish an agency that will disseminate information about successful energy conservation technologies and practices.

Project Description

1. Energy Management Company Demonstration

The core component of the project consists of demonstrating how EMC can work in China. Three EMCs will be established and operated as commercial businesses. The EMCs will adapt, operate, and develop energy performance contracting, as done by ESCOs in other countries, for the first time in China. The EMCs will undertake investment projects in host enterprises. Enterprises with limited knowledge of energy conservation will be able to implement energy-saving measures through the EMCs. The EMCs will finance the investment, shoulder most of the technical and financial risk, and initially own the equipment installed in the host enterprises. Income for the EMCs will come from a share of the energy savings actually achieved, according to a performance contract. After the EMC is fully compensated for its investment, operating costs, and risks, the equipment will be transferred to the enterprise, which will receive all future financial benefits. North American experience indicates that if the EMCs select good projects and manage them well, they should earn profits and grow steadily. Host enterprises will incur minimal risks and will eventually own efficient equipment. In addition, they will reduce energy costs without having to invest scare capital funds.

The three EMCs will first implement pilot projects financed by the European Commission (EC) and the SETC. Pilot project implementation will continue and expand with GEF and SETC financing during the first 2 to 3 years. The World Bank will support the replication of successful EC/GEF/SETC pilot projects and EMC growth through the International Bank for Reconstruction and Development. Project developers expect that domestic commercial banks will eventually become the primary source of financing for the EMCs.

2. Information Dissemination Component

The information dissemination component of the ECPP will increase China's capacity to collect information on the results of previous energy conservation projects (especially their profitability) and make the data available to enterprise managers. This component will be supported by GEF and Chinese government funds. An improved information development and dissemination program will be implemented through a national energy efficiency information dissemination center housed at BECon. Information will be provided free of charge, and the center's day-to-day operations will be supported by the Chinese government under contract. Key outputs of the center will include "best practice" energy conservation project case studies and technical guides, based in part on a successful government program in the United Kingdom. The best practice case studies for China will be based on projects that have already been implemented. The center will distribute its studies through existing governmental, industrial, and professional networks, using newsletters, presentations at training seminars, site visits, workshops, government conferences, and professional journals.

3. Program Management and Monitoring

Program management and monitoring will play an essential role in the ECPP. The World Bank and GEF will provide special support for monitoring. The SETC has formed a program management office (PMO) with officials from the Department of Comprehensive Resource Utilization and Conservation and personnel from BECon and ERI. The PMO is in charge of managing the entire program, including the establishment of the new EMCs and the information center. Support from the GEF will be provided for the following activities: a) training PMO staff and recruiting experts to assist in project management, monitoring and evaluation, developing policy recommendations on new energy conservation investment mechanisms, and disseminating lessons learned; b) supporting the development of proposals for new EMCs (pending completion of the first phase of the EMC project), and introducing these proposals to potential domestic financiers or foreign joint-venture partners; c) conducting a conference to introduce initial

results from the three demonstration EMCs and the EMC concept to Chinese investors; and d) preparing an expansion plan for the EMC project.

4. Phase II EMC Expansion Component

The Phase II EMC Expansion Component will accelerate the development of EMCs in other parts of China. It will support the development of a variety of EMCs, including joint ventures with foreign companies selected through an open and competitive process. The final design of this component will be completed during the implementation of the other project components. The expansion component will be based on the experiences of the three demonstration EMCs, and it will define specific barriers facing EMCs in China and recommend strategies to overcome them.

Institutional Structure

The SETC is the lead agency in the ECPP, but the State Planning Commission and the Ministry of Finance are also involved. The Department of Comprehensive Resource Savings and Utilization of the SETC supervises project preparation and implementation. This department has organized a project management office (PMO) with additional experts from the BECon and ERI. The PMO is also assisted by a variety of domestic and international consultants with backgrounds in project design, finance, law and others. In addition to coordinating the implementation of the EMC Demonstration Component, the PMO will implement the GEF-financed Information Dissemination, Program Management and Monitoring and Phase II EMC expansion components. There are similar project management offices at the three EMC project sites to coordinate project preparation and implementation at the local level.

The three pilot EMCs were established in mid-1996 as the result of a competitive selection process undertaken by the SETC. The EMCs are located in Shandong and Liaoning provinces and in the city of Beijing. They are publicly-owned, provincial-level companies. Each of the three EMCs was established according to China's Company Law with local shareholders. The EMCs will follow the ESCO model, and they will market, identify opportunities, finance, implement, monitor, and verify energy savings measures at no initial cost to customers. The EMCs will feature a variety of technologies, customers, and contracts . EMCs will operate independently, and the local and national PMOs and EMC boards of directors will only supervise the general direction of the business to ensure that EMC projects remain within the field of energy conservation. The EMCs will establish close relationships with enterprises, technology owners, equipment manufacturers, monitoring agencies, and financial institutions.

The energy efficiency information dissemination center will also operate as an independent organization under the supervision of the national PMO. The center will develop information products through subcontracts with host enterprises and monitoring institutions.

Project Support

The Chinese government has provided strong financial and institutional support for the EMC project. However, there is no precedent for performance contracting in China. Lack of on-the-ground experience with the EMC concept (which has required adapting to Chinese legal, financial, and regulatory systems) has constrained its development in China. No commercial entity is willing or able to incur up-front development costs, so foreign assistance and Chinese government support has been essential in the early stages of the project. The World Bank, the GEF, and the EC have all provided support to the EMC project because they recognize its energy efficiency and climate benefits..

Funds available for the entire project total $190 to $240 million. This amount includes a $5 million grant from the EC, a $35 million GEF grant, a $65 million World Bank IBRD loan, and $85 to $135 million from domestic sources such as government grants and commercial bank loans.

The three EMCs have contributed a total of RMB75 million ($9 million) in equity based on commitments of EC/GEF/SETC funds. The first demonstration projects will receive $5 million from the EC grant ($4 million for project implementation and $1 million for management). An additional $15 million grant from the GEF will be used for additional demonstration projects. A loan from the World Bank will be used to replicate successful demonstration projects and practices. The EMCs will also seek funding from domestic and international financial institutions after obtaining experience, capabilities, and a reputation over several years of commercial operation. A GEF grant of $13 million is proposed for the Phase II EMC expansion component. The Chinese and World Bank teams will seek additional counterpart financing and co-financing for Phase II as part of this component.

The financing required for the information dissemination component of the ECPP is estimated at $10 million over five years. The operation of the center and the information dissemination program will be supported with Chinese government grants at a cost of $1 million per year. $5 million in GEF funds will cover the incremental costs associated with the program, institutional capacity-building, and the analysis and dissemination of initial results. The estimated cost of the program management and monitoring component is $4 million--$2 million from GEF grants and $2 million from Chinese government matching funds.

Anticipated GHG Reductions

The project will contribute significantly to reducing carbon emissions. Over a 10-year period, the 3 EMCs are expected to reduce CO_2 emissions by more than 200 million metric tons. The information component of the project could save 26 million metric tons of coal equivalent by the end of the project's seventh year for a total reduction of 63 million metric tons of CO_2.

Progress to Date

1. Project Preparation (October 1994 to March 1995)

In 1994, China's National Environmental Protection Agency (NEPA), the State Planning Commission, the United Nations Development Program (UNDP) and the World Bank completed a 2-year study: *China: Issues and Options in Greenhouse Gas Emissions Control*. The study found that energy efficiency projects could yield attractive economic returns and realize large potential energy savings while reducing GHG emissions. However, only a small portion of potential projects were actually implemented because of market barriers. The SETC worked with World Bank representatives to explore practical approaches to energy conservation in China in follow-up to the study. Both organizations recognized that new market-oriented mechanisms should be introduced, and that international support for demonstration projects would be essential to building an energy service industry. The World Bank team held a series of discussions with the SETC introducing the GEF's principles and operating procedures. The two sides drafted a proposal for GEF/World Bank support.

2. Project Design (April 1995 to September 1995)

The SETC and World Bank teams agreed on the project objectives and the principle of GEF/World Bank support. The teams revised the draft proposal and designed the general project framework. The SETC, the lead agency on the Chinese side, established a project coordination group chaired by senior officials from the SETC and the SPC, who in turn set up a PMO staffed by governmental officials and energy conservation experts. BECon and ERI were designated as technical assistance units.

3. Development of Demonstration EMCs (October 1995 to June 1997)

Beijing, Liaoning, and Shandong were selected as sites for the EMC demonstration projects from nine cities who entered the selection competition. Each of the three EMCs registered as a commercial company under Chinese law. Local economic commissions also established their own PMOs to coordinate and oversee the development and operation of the EMCs. The PMO conducted a series of training courses and workshops with domestic and international experts. A World Bank/GEF mission, accompanied by representatives of the SETC PMO, visited the three EMCs and met with local officials from the PMO and relevant governmental agencies to evaluate the existing capability of the EMCs. They also reviewed the preliminary institutional and business plans of the EMCs and provided comments on the plans.

4. Project Appraisal (August 1996 - Present)

The EMCs revised their plans and conducted a detailed assessment of the Phase I demonstration projects supported by the EC. The World Bank/GEF mission conducted another on-site visit to evaluate the projects identified by EMCs focusing on technical feasibility, contract terms, and methodology of financial analysis. The mission also developed the framework for the National Energy Conservation Information Dissemination Center with the SETC PMO. The Executive Committee of the GEF approved the project in principal in April 1997. The World Bank/GEF mission visited China again in July 1997 to evaluate the Phase II demonstration project supported by the EC. The World Bank and GEF completed a final, formal appraisal in October 1997, and the project will begin full operation in the spring of 1998 after the Chinese government, the GEF, and the World Bank reach agreement on the GEF grant and the World Bank loan.

Project development and approval procedures for the World Bank and the GEF are complex. The formal GEF project will begin in the spring of 1998 if everything goes as expected. An encouraging sign is that the EC grant approval was signed by all parties and the money is now available to begin pilot projects.

The Chinese government has attached great importance to the introduction of EMCs into China. If successful, these market-driven industries will have a significant impact on energy consumption and carbon emissions throughout the country.

Case Study 3: Renewable Energy Programs: Wind Power Development

Background

Renewable energy is an important potential alternative to coal and other fossil fuels in China. Climate change mitigation experts consider renewable energy one of the most important options in the mid- and long-term future. At present, huge amounts of biomass are used in rural areas for cooking and heating, but applications are still primitive. China has initiated several programs to accelerate the development of modern renewable energy sources. These programs are a component of the country's sustainable energy development strategy.

Most modern renewable energy technologies are still not cost-effective compared to fossil fuels. Some technologies are competitive but highly dependent on specific conditions. Wind power is considered the most competitive modern renewable energy technology in many developed countries. In China, wind power is currently undergoing transformation from technical and economic pilot projects to real demonstration in commercial markets. The following case study concerns a grid-connected wind farm program.

The Grid-Connected Wind Farm Program

The Chinese government has given priority to wind power in developing renewable energy. Abundant wind resources exist throughout China. The technically recoverable potential is about 250 GW. By the end of 1994, 163 sets of wind power generators had been imported through bilateral cooperation with a total capacity of 30.1 MW. These generators were installed in 14 wind farms (see Table 1). In a few of the wind farms, generators of up to 550 to 600 kW per unit are currently being installed. Compared to the huge capacity of fossil fuel-fired plants that is being installed annually (15 GW, however, wind power accounts for a tiny fraction of the country's needs.

The government plans to install 1 GW of wind capacity by 2000 and 3 GW by 2010. Considering that the world's current total wind power capacity is only about 5 GW, this target is quite ambitious. The program is a combination of projects initiated by the SPC, the SETC, and the State Science and Technology Commission (SSTC). The SPC sponsored a program entitled “Cheng Feng” (Ride the Wind) that addressed key technical problems in wind power generation and increased the production capacity of wind power machines to facilitate the new industry. The SETC is focusing on the development of a wind power generation market to decrease cost and improve quality through competition and market penetration. The SSTC is in charge of research, development and demonstration for the initiative. The Ministry of Electric Power (MEP) is managing the project. Wind power development is considered a part of rural energy development for which the Department of Environmental Protection and Energy of the Ministry of Agriculture is responsible.

Table 1. Installed Capacity of Major Wind Farms through 1994

Location	Number of Units	Unit Capacity (kW)	Total Capacity (kW)
Dabancheng, Xinjiang	47	100, 150, 300, 500	12,750
Zhurihe, Inner Mongolia	28	100, 120, 250, 300	4,200
Nan'ao Island	27	90, 130, 150, 200	4,680
Pingtan, Fujian	6	55, 200	1,055
Hengshan, Liaoning	4	250	1,000
Donggang, Liaoning	6	55, 300	1,555
Chengsi, Zhejinag	14	20, 30	380
Shangdu, Inner Mongolia	17	55, 300	3,875
Dachendao, Zhejiang	5	20, 55	205
Rongcheng, Shandong	3	55	165
Changdao Island, Shandong	2	55	110
Dongfang, Hainan	1	55	55
Saihantala, Inner Mongolia	2	30	65
Cangnan, Zhejiang	1	55	55
Total	**160**		**30,100**

The MEP, SPC and SETC are primarily responsible for providing investment capital at the national level. Local governments and enterprises, both public and private, will invest as well. At the provincial level, the local electricity bureaus are the main investors and operators of wind farms. Investment from international sources is crucial for developing large-scale wind farms. Local manufacturers from the machinery, aviation, and shipbuilding industries are also investing in wind power equipment. Nearly 40 research institutions are involved in developing wind technology.

In the first phase of the project, the MEP identified possible sites for wind power development. Project developers also drafted a plan for meeting the government's target of new wind power generation capacity by 2000 using the sites identified (see Table 2). All of the sites feature abundant wind resources and are located near expanding power grids. The most attractive site is Huitengxile in Inner Mongolia. The region has good wind resources and is close to power centers in Beijing and Tainjing. One gigawatt of wind capacity will account for 2 percent of the total capacity of the regional grid. The central government and local governments have backed the proposed program.

Table 2. Technical Specifications from Wind Farm Case Studies

Technical Specification	Huitengxile	Nan'ao
Total Potential (kW)	1,000	75-100
Installed Capacity (kW)	100	11.2
Wind Speed (m/s)	8.8 (at 40m)	8.2 (at 6m)
Estimated Loss (%)	18	24
Annual Net Output (kWh)	335.1	33.5
Ratio of Operation (%)	39	34
Cost of Avoided Energy Utilization (kWh)	0.32 (3.8m)	0.30 (3.6m)
Financial Price (Yuan/kWh)	0.43 (5.2m)	0.46 (5.5m)
Economic Capital Cost (million Yuan, (million $))	750 (90)	89 (11)
Financial Capital Cost (million Yuan, (million $))	945 (144)	111 (13)
Unit Economic Capital Cost (Yuan/KW, ($/KW))	7,585 (915)	7,960 (960)
Unit Financial Capital Cost (Yuan,/KW ($/KW))	9,560 (1,150)	9,960 (1,200)

Average wind speed at the Huitengxile wind farm at a 40 meter elevation is 8.8 m/s. A 110 kV grid line crosses the farm, which lies near a highway running to the provincial capital 120 km away. Another 110 kV line is under construction which will also cross the field. About 100 km^2 of land are available to install 1 GW of wind power capacity. Developers will first install 100 MW of wind power with imported 550 kW generators. Their capacity factor has been estimated as 39 percent with annual production of 270 GWh (over 70 percent will coincide with the long daily peak period). Due to shortages in electricity supply, load management is commonly applied, leading to a longer but less sharp daily peak. Chinese experts estimate that the total capital cost for a 100 MW wind farm with imported turbines exempt from value-added taxes (VAT taxes) is 750 million Yuan ($90 million), or about $900/kW. If import duties are added, the cost of the farm will increase to 945 million Yuan ($114 million), or $1100/kW. The latter cost is higher than the cost of most wind projects in the international market.

Nan'ao, an island near the city of Shantou in Guangdong Province, is another promising site. The island has an area of 109 km^2. The island is connected to the grid in Shantou by 35 kV and 110 kV seabed cables. By the end of 1993, the provincial grid had a total generation capacity of 14 GW, with 76 percent of its capacity from coal and 24 percent from hydro power. Load demand has increased by an estimated 13 percent annually. Electricity generated from a new nuclear power plant is now on the grid. Forecasts indicate that generation capacity, including wind capacity, will exceed 23 GW by 2000.

The Nan'ao wind farm has very good wind resources, with average wind speeds at a 6 meter elevation measured 8.5 m/s. The local terrain makes 200 to 300 kW wind turbines more appropriate for the island. Total wind power capacity is constrained by land availability but could reach 75 to 100 MW. Developers have proposed building an 11.2 MW wind power station. The electricity generated will be transmitted to the provincial grid via the seabed cables.

Preliminary economic analysis indicates that the economic performance of wind power would be lower on Nan'ao than in Inner Mongolia. Given the much higher price of fossil fuel in the region, however, that situation could change.

The most important current issue for wind power development in China is economic competitiveness. While no grid-connected demonstration projects exist in China, a Chinese expert team has worked with the World Bank to develop a detailed economic assessment of the Huitengxile and Nan'ao wind farm demonstration sites, including cost-benefit analysis and economic analysis of both potential projects.

Table 3 provides the results of this analysis. According to the Bank's report, the "analysis is deliberately conservative, since there are uncertainties about installation costs, performance, startup times, operating costs of commercial wind farms on both sites."

Table 3. Internal Rates of Return (IRR) for Two Potential Wind Farm Sites

	Economic IRR (%, real)	Financial IRR (%, real)	Financial IRR on Equity (%, current)
Huitengxile			
Basic Case			
Today	10	10	13
Year 2001	15	18	38
Sensitivity on Today			
No Duty, VAT	10	19	30
Capacity Credit = Capacity Factor	13	10	13
Nan'ao			
Basic Case			
Today	5	7	10
Year 2001	8	11	16
Sensitivity on Today			
No Duty, VAT	5	15	23
Capacity Credit = Capacity Factor	11	14	22

For the economic analysis, the Bank's report commented "Wind farms are near to being economically viable in Huitengxile, even under conservative assumptions that power is valued only at the avoided energy cost and a full year commissioning time is required. According to the provisional data provided from the study, Nan'ao appears to be less attractive because it has a higher capital cost/kW, a lower capacity factor and lower avoided energy cost." Because these two sites represent one of the most favorably conditioned sites and one that is much less favorable, many of the other sites in listed in Table 1 would have rates of return that fall in between those of Huitengxile and Nan'ao.

Because the case study for these two examples assumed expensive imported wind generators, Chinese experts have suggested expanding local manufacturing capacity to include units of 500 kW and greater. This domestic production capacity could lower capital costs for the wind farm projects by 20 percent within five years. The commissioning time for the generators could also be reduced from one year to six months. These actions could significantly improve the cost effectiveness of wind farms in China. As the World Bank report notes, "This would make future wind farms at Huitengxile economically viable at 15 percent Economic Internal Rate of Return, even without a capacity credit. With cost reduction and a capacity credit equal to the capacity factor, Nan'ao Island would also appear to be close to economic viability at 11 percent." Domestic turbine production would make almost all the sites listed in Table 1 economically viable.

Because wind power is still in the demonstration stage, the Chinese government provides incentives for its development, including low interest loans, import duty exemptions, and income tax exemptions. Several companies have been established to develop and promote wind power. For example, the Ministry of Electric Power and the Inner Mongolian Electricity Management Bureau support the Beijing Fulin Wind Energy Development Corporation and the General Wind Power Company. Both of these companies are involved in developing wind power in Inner Mongolia. By the end of 1997, a new wind power station with a total capacity of 26.5 MW will be built in Xinjiang Province by the Xinjiang Wind Energy Company. This project is being financed by the German government.

To some extent, wind power is considered the only real alternative energy source that can play an important role in the future and add to the commercial energy mix in China. Compared to total recoverable wind resources of 250 GW, 3 GW is a very small amount, even if it seems ambitious for 2010. The results from the first group of commercial demonstration projects will determine the schedule of the commercialization and marketing of wind power technology. Government policies may remain favorable for another decade or more. Speeding up the domestic manufacturing capacity of wind turbines could decide the long-term economic viability of commercial wind power in China.

Proposed alternatives for the commercial development of wind power include direct foreign investment for wind power projects. Possible investment arrangements under discussion include build-own-operate (BOO) and build-own-transfer (BOT) mechanisms. In general, these financing mechanisms require power purchase contracts and other commercial contracting arrangements. Some local governments are considering incentives such as lower land prices or taxes.

The GHG mitigation potential of wind power in China is very significant. If half of China's potential wind energy is exploited (125 GW) with an average capacity factor of 30 percent, more than 210 TWh of electricity could be generated annually. This would offset more than 90 million tons of coal combustion, reducing carbon emissions by 60 million tons per year.

Conclusion

The three cases described in this paper represent three different types of mitigation activities in China. The CGLP was developed and initiated mainly by the Chinese government and Chinese enterprises. The primary goal of the program is not to mitigate GHG emissions, but to conserve energy. Multiple benefits, including energy conservation, environmental protection, improved grid power quality, and higher illumination levels, make this program a classic no-regrets activity.

The ECPP is an example of how a joint GEF/World Bank/government program can work in China. The characteristics of the program combine GHG mitigation with capacity building in the country's newly established market economy. The EMCs use only technologies that have already been proven technically and economically successful. Many barriers still must be overcome before the EMC project realizes its full market potential. China is a country in the midst of rapid development and structural change, where enterprises face the challenge of market competition for the first time. Managers are focusing on designing new high-quality products to meet the needs of a rapidly expanding market. Transaction costs to implement small-scale energy efficiency projects must be reduced. The ECPP program, which involves the largest allocation of loans to promote energy efficiency in the history of the World Bank, could soon break through many of these barriers.

Wind power farms are another type of mitigation activity that can generate economic and climate benefits. Wind power is currently in a demonstration phase, and the economic feasibility of grid-connected wind farms has not yet been established in China. However, it appears that wind generating facilities could soon become competitive. Modern renewable energy technologies are a challenge for China, as they are all over the world. International support is necessary to further advance these efforts.

Opportunities for greenhouse gas emission reductions in China are manifold. Because almost all of these opportunities are no-regrets activities, they can be implemented regardless of climate change policies. Strong government backing, however, is required to give confidence to the country's newly-formed market forces.

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