Technology Cooperation Framework - China

DRAFT

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1. Introduction

Chinese government declared in COP 3 that China can not make a commitment to reduce GHG emissions until it reaches an economic development level of medium-developed nations. But according to its sustainable development strategy, China will make great efforts to slow down the growth rate of GHG emissions. In 1994, the Chinese government formulated “China’s Agenda 21”. And some of its programs have been involved in the Ninth Five-year Plan and the Long-range Plan up to 2010. Based on above-mentioned standpoints, Chinese government participates actively in international cooperation activities for fulfilling UNFCCC. The Institute of Nuclear Energy Technology (INET) of Tsinghua University is one of the leading institutes to join international cooperation activities under the support of government. INET takes part in the research and implementation of AIJ projects in China. In addition, the new international cooperation mechanism to achieve GHGs mitigation, CDM, is also being researched at INET. Technology cooperation framework (TCF), one of the organization styles for international cooperation activities, is aimed at assisting developing countries to implement GHGs mitigation projects. However, an effective mechanism for devoting “Technology Cooperation Framework” should be established to communicate climate change technology needs of China to international donors under CDM or other feasible mechanisms. INET as well as other relevant organizations in China are interested in the role of TCF. With the assistance of the experts of NREL, a team for TCF has been organized and a draft framework has been prepared.

This report presents preliminary framework in China through consultations with technical experts from relevant ministries and institutes. This report should be viewed as a basis of further development of the technology cooperation framework. This work is also a part of continuing efforts following previous projects, such as “GHG Mitigation Technology Assessment and Development strategies” (supported by U.S. Country Studies Program), “Asia Least-Cost Greenhouse Gas Abatement Strategy” (supported by GEF/UNDP and implemented by ADB), and other local research projects in the fields of GHG mitigation strategies.

2. Background

China is a developing country and has the biggest population in the world. China’s area of cultivated lands only accounts for 7% of the world total, but it contains 21% of total population in the world. It has a long coastline, and its coastal area is densely populated and economically developed. Sea level rise would cause a large impact on the low-lying land. Water resources in China are limited, and not distributed in an even way. Furthermore, south-east monsoons from the Pacific Ocean and south-west monsoons from Indian Ocean are the main precipitation sources in China. They are easily influenced by global climate change. Generally speaking, China is located in an ecologically-vulnerable zone in middle latitudes and is very sensitive to and seriously threatened by global climate change.

In addition, China is a large emitter of GHGs in the world. The estimated energy-related CO_2 emission in 1996 were about 780 Mt-C, ranking second in the world. According to the analyses of different scenarios, CO_2 emission would reach 1,300~1,700 Mt-C in 2020 in China with the rapid growth of the economy.

Though China is facing an arduous task of developing its economy and improving people's living standards, Chinese government has been paying more attention to the issues of global climate change. As early as in February 1990 the State Council of China established the National Coordination Group for Climate Change (NCGCC), which consisted of representatives from 16 ministries and commissions, to lead and coordinate all works related to climate change issues. By the end of 1993, the members of NCGCC increased to 18 ministries and commissions, and four working groups were established:

(1) Working Group for Scientific Assessment.
(2) Working Group for Impact and Strategy.
(3) Working Group for Economic Analysis.
(4) Working Group for UNFCCC.

The institution in China for addressing global climate change was restructured in 1998, a new unit was set up which is entitled as Office to National Climate Change Policy Coordination Committee and located at State Development Planning Commission. Now the National Climate Change Policy Coordination Committee consists of 14 relevant governmental ministries and agencies.

In June 1992 Chinese government signed the UNFCCC, and subsequently ratified the convention. Since then, Chinese government actively participated in the activities for fulfilling UNFCCC, and played an important role in COP1, 2 and 3, and relevant negotiations. In the same period, many international cooperative projects related to GHG issues have been proposed, completed, or being carried out.

The main projects are as follows:

(1) National Response Strategy for Global Climate Change, supported by ADB, and implemented by SSTC.
(2) Issues and Options in GHG Emission Control (CPR/91/G32), supported by UNDP/GEF, and implemented by SPC/SEPA.
(3) China Climate Change Country Study and its following-up project, supported by USDOE, and implemented by SSTC.
(4) Development of Coal-Bed Methane Resources, supported by UNDP-GEF, and implement by Ministry of Coal.
(5) Beijing's GHG Emissions and Preliminary Control Measures, supported by Environment Canada, and implemented by SSTC/SEPA.
(6) Energy Efficiency Improvements in TVEs, supported by UNDP-GEF, and implemented by Ministry of Agriculture.
(7) Methane Recovery from Municipal Solid Wastes, supported by UNDP-GEF, and implemented by SEPA.
(8) Commercial Opportunities for New and Renewable Sources of Energy, supported by UNDP-GEF, and implemented by SSTC/ERI.

Since the eighth Five-Year plan, many national key science and technology projects on global climate change have been implemented, they provide a good foundation for the development of technology cooperation framework.

It should be pointed out that after COP 1, Chinese government started to initiate AIJ, up to now there are three AIJ project agreements signed:

(1) A coke dry quenching project in the Beijing Capital Steel-Iron Group Company, cooperated with Japan.
(2) A thermal power plant by using CFBC/CHP technology project in Shangqiu, Henan Province, Cooperated with Norway.
(3) A building energy efficiency project in Beijing, cooperated with USA.

At the beginning of this year the Chinese government started to study CDM. Chinese experts and officials took part in following activities:

(1) Research on implementing measures and strategies for CDM.
(2) An international workshop on CDM in Beijing in May, organized by IEA and Tsinghua University.
(3) Cooperative research by Harvard University and Tsinghua University.
(4) Workshops abroad organized by IEA and other Institutes.

Under these circumstances, it is undoubted that the establishment of technology cooperation framework (TCF) will promote and help the implementation of GHG mitigation measures in China.

3. Process for technology cooperation framework

The process used for preparation of the technology cooperation framework is as following:

(1) A team was established by the Global Climate Change Institute of Tsinghua University (TU) and the Administration Center for China's Agenda 21 (ACCA21) to develop TCF. There are five technical experts in this team. Since they all joined several of the international cooperation activities listed in above section, they are familiar with GHGs mitigation technologies and strategies in China. Especially, The above-mentioned first and third projects have close connections with the development of technology cooperation framework.
(2) An interagency consultant team, consisting of experts from relevant ministries and commissions, was established to help selection of technology priorities and provide guidance for the development of the options in the framework. These experts are from China Energy Conservation Investment Corporation; Energy Research Institute of State Development Planning Commission; Department of Planning of former Ministry of Electric Power; Hydropower Planning General Institute of former Ministry Electric Power; Coalbed Methane Clearing House of former Ministry Coal Industry.
(3) Research work on selecting technology priorities was carried out based on the results of domestic and international cooperative projects on GHG mitigation.
(4) A scooping meeting was held to discuss and evaluate the technology priorities.
(5) Research was conducted, market barriers and some key technology options to overcome these barriers were identified.
(6) This draft report was prepared and reviewed by the framework team.

4. Process for Screening and Validating Technology Cooperation Priorities

The current domestic studies reveal that energy intensity of GDP will drop down greatly from 1.92 kgce/US$ (90') in 1995 to 0.72 kgce/US$ in 2020, so energy efficiency improvement will be the most important strategy to abate GHG emissions. Another important strategy is energy substitution, especially renewable energy development. For a long period these are the two main areas where technical options for GHG mitigation should be focused.

Generally, there are many technical GHG mitigation options in the two areas. For identifying those options suitable for China's own situation, i.e. to consider obtaining not only possible maximum GHG mitigation through minimum cost but also national economic and social benefits as well as others, the method of AHP (analytic hierarchy process) is usually used for identifying and assessing GHG mitigation options.

Attended by international experts from the U.S. DOE, NREL, and domestic experts from SETC, SSTC, Ministry of Electric Power, Ministry of Agriculture etc., a scoping meeting of technology cooperation framework regarding China was held in Beijing. One of the tasks of the meeting was to identify the most priority GHG mitigation technologies in China practice. A simplified AHP approach (Analytic Hierarchy Process) was used in the meeting.

First, both international and domestic experts discussed and agreed on the following criteria for identification. The criteria were divided into four categories:

(1) environmental benefits
- GHG mitigation
- other pollutants reduction

(2) economic development
- new economic growth
- job creation

(3) conditions for technology transfer
- local capacity
- localization of manufacturing

(4) investment
- scale of investment
- investment time period
- state corporations
- private

Second, referring to these criteria, experts supposed the mitigation technologies based on their experiences in different sectors. After summarized, total 19 technologies were proposed, i.e.:

(1) high efficiency boilers
(2) large thermal power generation (300-600 MW)
(3) cogeneration
(4) high efficiency electric motors
(5) green lighting
(6) energy saving buildings
(7) coal-bed methane recovery and utilization
(8) biomass gasification
(9) wind energy
(10) solar thermal heat
(11) biogas
(12) waste heat and energy recovery

(13) village hybrid renewable energy (wind & PV)
(14) high efficiency cook stoves
(15) alternative fuel transportation for urban regions
(16) small-scale hydropower
(17) combined cycle natural gas power generation
(18) central heating
(19) waste gas recovery

Third, a matrix involving technologies and the criteria was designed and spread to only domestic experts to ask them making a score of each criterion of each technology. For simplicity, an equal weight here was assigned to each criterion. About 20 experts were questionnaired at the meeting.

Fourth, a comprehensive statistics was conducted, and finally the top five high scored technologies were identified, they were thermal power generation, high efficiency motors, high efficiency boilers, wind energy and coal bed methane recovery.

Approximate estimation of GHG mitigation potential, including CO_2 and CH_4, for the five priority technologies and the accumulated investment required for achieving full potentials are presented in Table 1.

Table 1 Estimation of GHG mitigation potential and required investment (2005-2010)

Priority technologies	Annual GHG mitigation		Accumulated investment	
	CO_2 (Mt-C)	CH_4 (Mm^3)	(by billion Yuan)	(by billion US$)
1. CFBC	2.4		165.0	19.9
2. HE Motor	16.5		26.6	3.2
3. Boiler (increasing efficiency)	22.0		40.0	4.8
4. Wind power	0.63		10.0	1.2
5. CBM power generation	0.26	4.86	2.4	0.3

Notes: 1. Supposing the exchange rate : 1 US$ = 8.3 Yuan.
2. Total mitigation for CBM power generation is 1.03 million tonnes of CO2 equivalent.

(1) Annual mitigation potentials of the five priority technologies are estimated based on proposed development programs and current technology level in some relevant industries. However, because the development programs in some industries are still being modified, obvious changes of current equipment, technology level and management status may happen, so the above figures should be considered as rough estimation only.

(2) Accumulative investment, here, refers to the total investment needed to obtain the expected targets of technology diffusion, instead of the incremental costs relative to baseline technologies. In addition, accumulative investment is estimated by using constant prices.

(3) Among these GHGs mitigation technologies, some have much lower operation costs than current technologies, even being considered as “no-regrets” technologies, such as some projects of high-efficiency electric motor and industry boilers. However, there would be some difficulties in raising funds under current mechanism. TCF may provide assistance in solving this problem.

(4) China has achieved some beneficial experiences from past technology diffusion conducted through either international cooperation projects or domestic projects, such as industry boiler replacement, wind power generation and so on. These experiences will help to promote future technology diffusion through TCF and other mechanism.

5. Technology Priorities

5.1 Higher efficiency power generation technology: CFBC

5.1.1 Background

It is China's policy to enhance transformation efficiency of primary energy and utilize the existing energy resources fully and properly. Coal accounts for 75% of total primary energy of China and power generation is the major consumer of coal. Coal used for power generation accounts for 35% of coal production in 1996. With the development of the Chinese power industry, this proportion will increase in the future and is estimated at 40% in 2000. Therefore, the efficiency enhancement of coal-fired power plants and energy conservation is the important measure to protect the atmospheric environment and reduce greenhouse gas.

At present, circulating fluidized bed combustion (CFBC) is a maturing and advanced technology for energy conservation and environmental protection throughout the world. Its application in power industry is expected to be a primary area for clean coal technology development at present and in the 21st century.

5.1.2 GHG Reduction Potential of CFBC Technology

At present, the average power generation efficiency in China and the whole world is about 30%. The efficiency of a CFBC power plant can be up to 40%, or 48-50% for PFBC-CC.

At the end of 1997, total power installed capacity of China was 250 GW. It will be up to 300 GW in 2000 and 700-800 GW in 2020. Among this new increased capacity, coal-fired power plants will account for 75%. Therefore, enhancement of coal-fired power generation efficiency through application of CFBC technology can save a large amount of energy (coal) and greatly reduce carbon dioxide emissions, which will play an important role in GHG reduction in the world. At the same time, because CFBC technology can simultaneously remove SO_2 and NOx generated in coal combustion process, it has a great and un-replaceable role in environmental protection.

5.1.3 Main Barriers for Application and Popularization of CFBC Technology in China

Main barriers for application and popularization of CFBC technology in China are as follows:

(1) Research and development capacities. Funding and technical support for R&D activities are needed.
(2) Economic incentives for CFBC power plant construction. There is a need to study economic and financial feasibility of CFBC power plant and define concessionary polices such as financial, tax and tariff policies.
(3) Capital and investment funds availability for CFBC power plant construction. There is a need of foreign investors to provide capital and investment and jointly construct CFBC power plant with Chinese partners.
(4) Designing and manufacturing capability for CFBC equipment. There is a need for foreign manufacturers to transfer designing and manufacturing technologies and jointly design and manufacture equipment of CFBC power plant with Chinese companies.
(5) Construction and installation capability of CFBC power plant. There is a need of foreign engineering contractors to jointly construct and install CFBC technology in power plant or to provide engineering consultants.
(6) Operation and management capability of CFBC power plant. There is a need for foreign institution to provide operation and management training for Chinese operators and

managers.

5.1.4 Present Achievements and Future Planning of China on CFBC Technology

China has some experiences in CFBC power plant with small boilers (10-75t/h), corresponding to the foreign technological level at beginning of the 1980's. An CFBC generation unit of 100 MW imported from Finland has been constructed in Neijiang Power Plant of Sichuan province. Before 2000, China will strengthen technological assimilation of imported 100 MW CFBC units, especially design and manufacture technology of main and auxiliary equipment, and speed up the localization process of large capacity CFBC technology. China will also import, study and develop CFBC technology and equipment of 300 MW capacity and strive by every means to construct a demonstration power plant of 300 MW CFBC technology in 2000.

Investment of 300 million US$ and research and development funds of 3 million US$ are required for a 300 MW CFBC demonstration power plant. For a 100 MW PFBC experimental power plant, investment of 100 million US$ and research and development fund of 3 million US$ are needed.

China has some experiences in CFBC power plant using small-size boilers, e.g. 10-75 ton/hour, corresponding to the technological level in early 1980s in the world. A CFBC generating unit with a capacity of 100 MW imported from Finland has been put into operation in the Neijiang Power Plant in Sichuan province.

Before 2000 China will strengthen the assimilation of imported CFBC technology, especially the design and manufacture of key components and auxiliary equipment, and speed up localization of CFBA technology. China will also import, learn and develop large-scale CFBC technology and equipment and try to build a demonstration CFBA power plant with a capacity of 300 MW in 2000.

For developing CFBC technology, 5-10 million US$ of technical assistance are needed in the form of grant. Total investment of the 300 MW CFBC demonstration project is estimated to be 300-320 million US$, and it is hoped to find long-term and low interest loans from donors. The State Power Corporation is acting a major role in promoting this priority technology.

Table 2 gives a brief overview of CFBC technology, its development barrier, donor action, domestic action and future work needed.

Table 2 Priority Technology for CFBC Technology

Development Barrier	Donor Action	Domestic Action	Future Work Needed
Local ability to research and develop CFB Ckey technologies	Provide research and development fund and consultant	Provide research and development fund and establish research and development network	Define CFBC key technologies for research and development
Local economic incentives for construction of CFBC power plants	Provide economic and financial study fund and consultant	Study economic and financial barriers of CFBC power plant construction and removing measures	Request government to give some economic and financial concessionaire policies to CFBC power plant construction
Local ability to do feasibility study and detailed design of CFBC power plant	Provide feasibility study fund and identify international consulting company	Identify local consulting company and site of CFBC power plant	Provide training for Chinese design personnel
Availability of investment	Provide part of capital and investment	Identify local investors	Establish CFBC power plant company
Local capability to design and manufacture equipment of CFBC power plant	Identify international manufacturer of equipment and provide technology transfer	Identify local manufacturer and its manufacture ability	Define area of technology transfer and joint-manufacture method
Local capability to construct and install CFBC power plant	Identify international engineering contractor or engineering consulting company	Identify local engineering contractor and its construction ability	Define joint-construction method or consulting method
Local capability to operate and manage CFBC power plant	Identify training institution for operators and managers	Define operators and provide preliminary training	Define support method of operation technology

5.2 High efficiency electric motor (HEEM)

5.2.1 Background

Motors are the most important energy end use equipment in China. It is estimated that the electricity consumption of motors accounts for more than 50% of the total amount of the whole country. Currently, the total installed capacity of all types of motors exceed 400 GW in China, with electricity consumption of about 600 TWh. Among the motors, which are actually being operated in China, the 0.55-100 KW three-phase asynchronous motors are the main part, in which, 70% are JO2 series, 30% are Y series. The former is similar to the technology level of the 1950's of the world, and the latter similar to the technology level in the late of the 1970's. Compared with those of foreign countries, the motors made in China are inferior in such aspects as energy efficiency, operation lift cycle, operation reliability, material usage, noise and vibration, etc.

In recent ten years, the related departments of China's government have paid greater attention to the fields of motor energy saving. The manufacture and utilization scale of high efficiency motors is being gradually enlarged, and the efficiency of motor's driving system is being gradually increased. But generally speaking, the efficiency of China's motors is 3 to 5 percent lower than that of foreign motors on an average level, and the system efficiency during actual operation process is 20 to 30 percent lower than that of foreign motors.

The main reasons for low motor efficiency in China are: (1) high efficiency motors manufactured and utilized is in a low amount. (2) The energy efficiency of motors during operation process is low. (3) The maintenance service for motors can not hold and improve the motor's efficiency.

5.2.2 GHG Reduction Potential of HEEM

The available technology options can be divided into three aspects:

(1) Popularize high efficiency motor. If China can install high efficienct motors (annually 6.5 GW) in newly manuafactured machines and equipment and accelerate the substitution of low efficiency motors (annully 5 GW), annual electricity saving can reach 15.5 Twh by 2010 which equals a CO2 abatment of 4.6 Mt-C annually.
(2) Use adjustable-speed motors. The electricity saving rate is 10-25% if low efficiency speed adjustment technology is adopted, and can reach 20-50% for high efficiency speed adjustment technology. According to statistics on such industries as metallurgy, chemical industry, bulding material, etc., the energy saving potential in promoting speed adjustment operation of motors is 40 TWh annually, equal to an annual CO2 abatement of 12 Mt-C.
(3) Efficient maintenance and repair of motors. Adopting advanced energy saving maintenance technologies can increase motor's efficiency by 1-10 percent. Annual electrity saving can reach 9.6 TWh, which equals to CO2 abatement of 2.9 Mt-C annually.

5.2.3 Main barriers for HEEM implementation

The main barriers for this technology's implementation are:

(1) Lack of competitiveness of Energy efficient motor in Chinese market.
(2) Lack of awareness of energy efficient motors.
(3) Lack of energy efficiency service institutions specified on motor driven system.
(4) Lack of qualified motor repair service.
(5) Lack of appropriate and practical information of energy efficiency motor driven system retrofitting.
(6) Less local manufacturers.

5.2.4 Present initiatives and future work needed

In order to fully solve the problem of lower gross energy efficiency of China's motors, various macro measures may be adopted including adjusting energy policies, strengthening energy saving regulations and laws, and rationally fixing energy (electic power) price. In addtion to these, other options and measures can be implemented to improve the market for high efficient motors, the detailed measures from the following aspects should be taken:

(1) To increase the market competitiveness of high efficiency motors in China.
(2) To guide and encourage enterprises to increase motor efficiency.

(3) To invest the construction of joint venture of HEEM, including the manufacture of drawing system devices.
(4) To establish energy saving service system which can meet market demands.
(5) To establish service centers for motor maintenance and repair, increase motor maintenance and repair level.
(6) To establish effective system for dissemination of motor energy saving information, especially the benefits.
(7) To initiate a demonstration project in one large-scale enterprise for HEEM and renovation of drawing system.
(8) To conduct a more detailed market survey of HEEM.

The hoped foreign funding for removing barriers in promoting HEEM in China are summarized in annex table 1.

A brief overview of motor sector in development barrier, donor action, domestic action and future work needed is shown in Table 3.

Table 3 Priority Technology for Motor Sector

Development Barriers	Donor Action	Domestic Action	Future Work Needed
Lack of competitiveness of Energy efficient motor in Chinese market	Assistance in introducing advanced technologies and equipment into China, identifying partner for joint ventures	Increase input on R&D, regulate market behavior, provide favorite market condition for energy efficiency motor manufactures, encourage introduction of energy efficiency motor technologies and equipment	Following up technology development in world, analysis on feasibility of introducing advanced technologies and equipment, and relevant policy research
Lack of awareness of energy efficiency of motor driven system	Support for educational and training programs and pilot projects	Improving awareness of benefit of energy efficiency motor driven system, conduct pilot project on energy efficiency motor driven system, improve production and quality of ASD in China	Following up technology development in world, analysis on feasibility of introducing advanced motor operation control technologies and equipment, conduct pilot project on retrofitting of motor driven system
Lack of energy efficiency service institutions for motors	Introducing experiences of energy efficiency services systems, financial and technical support for establishing and developing energy efficiency services	Establishing energy efficiency service institutions with financial and technical capabilities	Introducing methodologies and experiences of ESCo in developed countries, analysis on feasibility of developing energy efficiency service institutions in China
Lack of qualified motor repair service	Introducing advance motor repair technologies and experiences into China	Regulating market of motor repair service, introducing and diffusing energy efficiency motor repair service	Establishing pilot motor repair service center
Lack of appropriate and practical information on energy efficiency motor driven system retrofitting	Assistance in establishing effective information collection and dissemination system in China	Collecting practical information on energy efficiency motor driven system retrofitting, establishing effective information dissemination systems	Identify appropriate content and methodology for information collection and dissemination, and establish effective info dissemination systems

5.3 Advanced industrial Boilers (increasing the thermal efficiency)

5.3.1 Background

From 1991 to 1995 the total production of industrial boilers reached 433 thousand, 254 thousand for new installed capacity, 179 thousand for boiler. By the year of 2010, the average growth rate of industrial boiler use will be around 3% and the vaporization will increase by 6%, which means the number of industrial boilers will reach about 800 thousand at total 2.5-2.6 million steam-ton.

5.3.2 Potential GHG Reduction of Industrial Boilers

At present, energy consumption of boilers is quite high. The potential for energy conservation is huge, because the average thermal efficiency is 10-20% lower than foreign industrial boilers.

In 1995, 0.5 million industrial boilers were in operation, with annual coal consumption of 277 Mt. Boilers are one of the largest coal consumers and one of the main air polluters. The annual dust emissions in 1995 were 4Mt accounting 24% of national total dust emission. Carbon emission of total industrial boilers were about 132 Mt-C, in which 102 Mt-C was from boilers used in industrial production, and 30 Mt-C from those of non-production use.

By the year of 2010, the total numbers of industrial boilers will be 807 thousand. Supposing major measures, such as high efficiency industrial boilers, fuel type shift, and increase of unit volume of new industrial boilers, are adopted, the overall thermal efficiency of boilers will be higher 3.5-5%, and operation thermal efficiency higher 5-7% than those in 2000.

Based on the different type of coal consumption and different inventory factor of coal, the potential for GHG reduction is 20-23 Mt-C/yr.

5.3.3 Key barriers to the technology's implementation

At present the adoption of efficient industrial boilers is occurring slowly, because of the large number of boilers. The main barriers may include:

(1) Funding shortage for retrofitting old boilers and purchasing more efficient boilers.
(2) No proper mechanisms established to promote renovation of boilers and diffuse high efficiency combustion technologies.
(3) Unsteady fuel quality.
(4) Lower technology level of operation and maintenance.
(5) Lack of technical information on efficient boilers.
(6) Poor management of boiler use.

5.3.4 Current Initiatives and Needs for Further Implementation

(1) GHG Emission Reduction Technologies in Industrial Boilers

The main GHG emission reduction technologies in industrial boilers are to: (a) restructure the fuel mix by means of reducing coal-fired boilers, and increasing oil and gas-fired boilers. (b) Adopt clean coal technologies. (c) Increase high thermal efficiency of coal-fired industrial boilers, retrofit existing low efficiency boilers. (d) Develop district heating. (e) Develop cogeneration.

(2) Investment Required to Achieve the Target of Efficiency Improvement

According to the average investment 800-900 Yuan for reducing one ton of coal with efficient boilers, it is estimated that the total investment needed will be 35-44 billion Yuan to achieve a GHG reduction of 21-23 Mt-C/yr.

China is interested in the Joint Ventures for efficient boiler manufacture, installation and maintenance. Foreign funding is needed for removing barriers in promoting efficient boilers in China. The suggested foreign funding and others are summarized in annex table 2.

Table 4 presents a brief overview of advanced industrial boilers development barriers, donor action, domestic action and future work needed.

Table 4 Priority Technology for Advanced Industrial Boilers
(Increasing the Thermal Efficiency of Boilers)

Development Barrier	Foreign Action	Domestic Action	Future Work Needed
Lack of funds for renovation of old boilers • Lack of funds sources • How to repay loans with benefits	Identify foreign partners and investors. Help design repayment mechanisms for loans. Assessment of renovation plans and relevant measures.	Research and assess investment and repayment mechanisms. Research and formulate relevant policy and regulation.	Based on TCF project to search for ways of funds. Identify potential donor and domestic funding sources
Mechanisms to promote renovation of boilers and spread high efficiency burning technology. Lack of relevant information	Introduce foreign experiences. Consult and cooperate in establishment of energy conservation service company. Consult and help in information and training	Set up a pilot of energy conservation service company. Research and formulate relevant policy and regulations. Enhance dissemination, education and training. Establish and improve information network.	Formulate policy and regulations with the implementation of Energy Conservation Law. Design pilots of energy conservation service companies. Set up the information network. Disseminate linking with TCF projects.
Operation management of boilers is not good. Fuels quality can not be guaranteed .	Introduce foreign experience for operation management and fuel supply mechanisms.	Improve the regulations for operation and management for boilers. Improve coal markets and markets for other fuels.	Design relevant activities linking with other projects.
Training for operation management and technical maintenance is not at a high level.	Consult and help to implement training program	Organize and support training courses.	Search for international cooperations to organize training courses.

5.4 Wind power

5.4.1 Background

The main benefits of wind power generation are its economic competitiveness, its environmental benefits, and the fact that it does not cause waste production, resettlement problems. In 1997 there were 19 wind farms with 433 turbines nationwide with total installed capacity is 167 MW. Annual electricity production was up to 400 million kWh.

5.4.2 Mitigation Potential of Wind Power Generation Technology

Grid connection wind power is the most economic way of utilizing wind energy in a large scale. During the past 20 years great progress has been achieved in this technology, with 1.5 MW capacity now entering the market. Even though the cost of wind technologies are still high, the costs are going down continuously. At the same time, the costs of fossil fuel fired conventional power plants will go up, due to the decrease of resources and more strictly environmental rules.

The wind energy resources that can be economically utilized in China is estimated up to 253 GW. This amount is even larger than the total installed capacity of power industry nationwide in China. It shows that China is rich in wind energy potential. However, the real exploitable wind energy resources need be investigated in more detail.

Based on the above mentioned assessment, 630 TWh of electricity could be generated by wind annually, and 700 million tons of CO2 emission might be mitigated.

5.4.3 Key Barriers to the Implementation of Wind Power Generation Technology

The main barriers are:

(1) Availability of resource and cost data

There is a lack of funding support for detailed investigation of wind energy resources. Very few on-site measurement data has been obtained, making accurate assessment more difficult. Further information on costs of wind power technologies is also needed.

(2) Local capacity to manufacture, install, and operate turbines

Domestic manufacturing is needed for large scale development, but very high inputs are required for prototype R&D projects and commercialization. Currently it is difficult to introduce foreign technology, there is a need to incense the proportion of domestic made components gradually. It is expected that 20 to 30% of cost could be reduced compare to imported machines by employing local made main components.

(3) Financing to purchase turbines

There is great difficulty in mobilizing funds, especially equity finance. Interest rates for domestic commercial bank financial are very high.

(4) Lengthy approval process for wind farm projects

Usually two years is needed from issuing project proposals to sign an equipment procurement contract, even 3 MW wind farm project, have to be approved by the SPC.

(5) Awareness of environmental benefits of wind power for local air pollution control

Many people considered that wind power is a small decentralized home power system, impossible to develop in large scale, and high cost for unstable power supply, less attention to be paid on wind power development. There is not widespread awareness of the benefits of wind power in addressing air pollution.

5.4.4 Current Initiatives and Needs to Promote Implementation

(1) There are national programs currently in place to promote the use of wind power generation technology

By the end of 1996, about 140,000 small-size wind generators with a total capacity of 19 MW were put into operation. In addition, the total capacity of large-size wind power systems in grid-connection exceeded 57 MW.

According to the document of "Outlines for New and Renewable Energy Development during 1996-2010" by SPC, SETC, and SSTC in 1994, by the end of 2000 and 2010, the total wind farm capacity will increase to around 1 GW and 3 GW, respectively.

Domestic manufactures will increase their capacity building to produce wind generators totaled 200 KW a year. For implementing wind power development, the State Power Corporation is considered the most proper unit.

(2) The potential for increasing the use of wind power generation technology

Many small coal fired power plants have to be phased out due to high consumption of coal and air pollution. Large thermal power plant construction is also limited to be located at the mouth region of Yangtze river. It provides a good opportunity to develop wind power.

(3) Investment required to achieve the development target

For reaching the wind power development target, huge investment requirement is needed. Now there is an international cooperation project supported by the World Bank being processed. The objective of the project is to build wind power generating capacity 190 MW, investment includes two part, one is from the World Bank being 100 million US$ that mainly used for purchasing key equipment of wind generators. The other is domestic sources of 2 billion Chinese yuan. The project is expected to be signed in March 1999 and hoped to be completed fully in 2000-2001.

(4) Other cooperation ways for promoting wind generation technology

Low interest government loan is available from Denmark, Germany, the Netherlands, Spain and USA etc. Funds from international financing organizations are also available. For example, there was a project of wind power in Inner Mongolia Autonomous Region between China and Denmark to install nine wind generators with an unit capacity 600 KM each. The equity, 20% of total investment, was prepared by the owner, the remained came from loans. Funding from Denmark side was a mix financial support including both government grant and low interest loan that mainly used for importing Danish generator cores. The rest investment was borrowed from domestic banks with favorable conditions set specially for promoting renewable energy development, i.e. import tax and loan interest are cut down by 50% after the fulfillment and verification of the project.

The other way is to establish joint venture. For example, some agreements to form joint ventures between two Chinese manufactures bided and two foreign wind generator companies have been signed, respectively.

Table 5 presents a brief overview of wind power in development barrier, donor action, domestic action and future work needed.

Table 5 Priority Technology: Wind Power Generation

Development Barrier	Donor Action	Domestic Action	Future Work Needed
Availability of resource data	Funding and technical assistance for data collection	Implement wind resource assessment and create data center	Define geographic scope
Local capacity to manufacture, install, and operate turbines	Identify international investors and provide training and financing for new wind turbine companies and joint ventures	Identify local investors and expedite approval of new businesses and joint ventures	Characterize market potential for wind turbines
Financing to purchase turbines	Provide technical assistance and speed funding for revolving loan funds	Establish project companies to manage loan funds and provide matching seed funding	propose design for loan funds
Lengthy approval process for wind farm projects	Technical assistance in identifying approaches to expedite approval of wind farm projects	Implement actions to streamline wind farm projects approval	Identify opportunities to streamline approval
Awareness of environmental benefits of wind power for local air pollution control	Provide data and tools for estimating air pollution benefits of wind power over conventional energy technologies	Disseminate tools to local environment protection authorities and promote consideration of wind power as an alternative to conventional energy sources	Identify local users who would most benefit from this tools

5.5 Coal bed methane (CBM) power generation

5.5.1 Background

In 1996, there was a total of 146 mines installing CBM drainage systems. The total CBM drained was 630 million m^3, of which 480 million m^3 was utilized. In the same year, the total amount of CBM vented to the atmosphere through coal mining reached 7.7 billion m^3. It is planned that by the year 2000 an additional 115 new methane drainage systems will be installed. By then, the total amount of methane drained will reach 1 billion m^3 annually. Moreover, CBM surface development has also made significant progress in recent years. A total of nearly 100 surface wells have been drilled in more than 30 coal mining areas since 1990. It is predicted that CBM production by surface wells will reach 1 billion m^3 by 2000.

Currently, CBM drained from underground coalmines in China is mainly used as household fuel, and a small amount is also used as fuel for industrial boilers, for power generation and as feedstock for chemical production. CBM power generation is a practical utilization option in mining areas. It can use both the medium heating value (~35% CH_4) and high heating value (>90% CH_4) CBM. CBM power plants are generally small in scale and are mostly used as on-site power plants.

5.5.2 GHG Reduction Potential of CBM Power Generation

The cost of power generation for CBM-fired power plant is 0.32 Yuan/kWh as compared to 0.25 Yuan/kWh for that of conventional coal-fired power plants. CO_2 emission for per kWh electricity using coal and CBM are respectively: 0.27 kg-C/kWh and 0.13 kg-C/kWh leading to a CO_2 reduction of 0.14 kg-C/kWh. So the incremental cost of CO_2 reduction for CBM power generation is 500 Yuan/t-C.

In 1996, the amount of CBM vented to the atmosphere from recovered gas reached 154 million m^3, which can be used to generate 586 million kWh electricity if fully utilized, representing a saving of 0.2 Mtce. The combustion of 154 million m^3 methane releases CO_2 of 0.08 Mt-C whereas the combustion of 0.2 Mtce coal releases 0.16 Mt-C, representing a CO_2 emission reduction of 0.08 Mt-C. Meanwhile, 154 million m^3 CH_4 emission removed.

5.5.3 Barriers for Popularizing CBM Utilization

Five main barriers for popularizing CBM utilization are identified:

(1) Lack of capital

CBM power generation requires large investments with an estimated cost reaching US$ 800~1000 per kW installed capacity. On the other hand, coal mining enterprises have relatively poor financial situation. This makes it very difficult for the coal mining enterprises to raise the necessary capital for the construction of CBM power plants.

(2) Lack of information and trained personnel

Only three small CBM power plants have been built in China (including the one only run in summer in Fushun). These plants have been in operation for a relatively short period of time. There is a great shortage in CBM power plant design, construction and operational data.

(3) Lack of production capacity for large size gas engines

Currently, the largest size gas engines that can be produced in China are 600 kW which is too small for establishing large size CBM fired power plants. Internationally, gas engines of 1,000 kW and internal combustion engines of 2,800 kW and over are readily available. However, imported gas engines are too high in cost affecting the popularization of this technology.

(4) Low electricity prices

Currently in China, the electricity distributing company has a monopoly on the national power grid and the price of electricity is set by the government. The low electricity price has become the restricting factor for establishing CBM power plants. CBM power plants normally have higher generation cost than coal fired power plants making it less competitive.

(5) Lack of environmental protection awareness

Up to now, China has not issued any mandatory measures to reduce GHG emission. Local government in mining areas and coalmines use CBM mainly for improving energy structure and atmosphere pollution not from the point of reducing GHG emission reduction.

5.5.4 Work Done to Date and Future Work

(1) National plan to promote CBM power generation

CBM development and utilization is listed in the optimal projects for China's Agenda 21, in which the Panzhuang and Liulin CBM development projected are included. In addition, CBM development and utilization is also included in the "Clean Coal Technology Development plan for the 9th Five Year Plan and Outline to 2010". It is planed to strengthen research on CBM exploration and development technology and select promising areas for the construction of CBM comprehensive development and utilization demonstration projects.

(2) Potential to increase utilization

Based on the mine CBM recovery efficiency and utilization, it is expected that total amount of CBM available for power generation by 2000 will reach 243 million m^3 generating electricity 924 million kWh and replacing 348,000 tce. The combustion of 243 million m^3 of methane release 440,000 t of CO_2 and the combustion of 348,000 tce of coal releasing 926,000 tonnes of CO_2. This represents a reduction of 486,000 tonnes of CO_2. On a gram to gram basis, methane is a more potent greenhouse gas than carbon dioxide (more than 20 times that of CO_2 over a 100 year period). If not utilized, the release of 243 million m^3 of CH_4 represents a CO_2 equivalent of 3.42 million tonnes.

(3) Investment need for full utilization

Internationally, the cost for the construction of CBM fired power plant is approximately 8,000 Yuan/kW. Assuming a total 243 million m^3 of methane is available for power generation and average operating hours of 6,000 annually, it will be sufficient to install power plants with a total size of 152 MW. The total investment required is then, approximately 1.22 billion Yuan.

Foreign funding for CBM priority technology promotion in actions to address barriers is estimated in annex table 3.

(4) Other cooperation options to increase the CBM power generation

The following options are identified:

a) Setting up joint venture for the construction of power plants and the foreign partner can use power generating equipment as shares;
b) In view of the environmental benefits of CBM power plants, soft loans can be applied for from international monetary organizations and foreign governments;
c) Domestic joint ventures between coal mining administrations and power companies;
d) Technological cooperation with relevant foreign companies to introduce advanced gas engine production technology and setting up joint ventures in China for the production of power generating equipment.

Table 6 presents a brief overview of CBM utilization in development barrier, donor action, domestic action and future work needed.

Table 6 Priority Technologies of CBM Utilization
(Power Generation Using Gas Engines)

Deployment Barrier	Donor Action	Domestic Action	Future Work Needed
Financing: high capital investment; Lack of credit	Providing soft loans or grants towards the construction of CBM fired power plants; seeking foreign investors or partners.	Provide matching fund and necessary facilities	Identifying economically and environmentally sound projects for support
Lack of information and shortage of trained personnel	Provide technical training, on gas engine-based power generation; provide training on international standard feasibility study and financial analysis for CBM-fired power plant projects.	Creating information training programs for key persons; developing business plan and bankable projects.	Continue to collect information related
Lack of local capacity to manufacture large size gas engines	Seeking international manufactures for new gas engine company or joint ventures locally	Identifying local investors and expedite approval of new business or joint ventures	Characterizing market potential for gas engines
Low Electricity price to local power grid for methane fueled power plant owned by coal mining administrations	Technical assistance in identifying approaches to get power purchase agreements with good price	Use the electricity generated on site instead of purchasing electricity or directly transmit the electricity to users	Identifying direct users or establish joint venture power projects with local power company
Awareness of environmental benefits of methane fired power plant for local air	Providing data and tools for estimating air pollution benefits of methane fired power plant over coal fired	Disseminating tolls to local air pollution authorities and promote consideration	Identifying local users who benefit from methane-fire power generation

pollution	power plant	of gas engines as an alternative to conventional energy sources	

5.6 Summary of Proposed Actions for the Priority Technologies

In order to assist the implementation of preferential mitigation technologies, relevant departments of the government need to strengthen studies on how to remove the barriers and promote the implementation. Proper and effective ways should be analysed and evaluated for raising funds, expediting the reconstruction of institutions and organizations, formulating necessary policies and regulations, improving market mechanism, expanding international cooperation, and selecting and implementing demonstration projects.

5.6.1 Domestic Actions

Undoubtedly, government measures with economic and price reforms will enhance the profitability for the implementation of preferential mitigation technologies. These economic reforms will not be discussed in more detailed here, because their targets are not focused only on the GHG mitigation. This discussion focuses on actions that go beyond present economic reform.

(1) Establishing favourable financing mechanisms

The government is making efforts to create favourable policies for stimulating investments in energy conservation technologies and projects. The government should expand the scope of these programs to promote renewable energy and alternative energy, and intensify efforts to promote energy efficiency.

(2) Conducting institutional restructuring

In China, the government is carrying out restructuring of governmental institutions, with emphases on separating the governmental administrative functions from the production management functions. A mechanism that may help to promote GHG mitigation technologies should be embodied in the institutional restructuring. This period of restructuring should promote appropriate policy reforms and create new appropriate institution if necessary.

(3) Importing and mastering technologies and management

To make rapid progress in the production and management of some priority technologies, it will be important to improve the understanding of foreign advanced technologies. The responsible administrative departments of the government should work together with the institutions, which are in charge of organizing and implementing technology import, to formulate plans and programs of learning and using these technologies.

(4) Training personnel

Involvement of a large amount of skilled personnel will be a necessary guarantee for the successful implementation of diffusing priority GHG mitigation technologies. The government needs to establish programs and legal guidelines to conduct and guide the personnel training activities.

(5) Enhancing information exchange and dissemination

With the support and help of international organizations and experts, the government should organize and coordinate relevant institutions to establish a common information management system so as to strengthen and assist information exchange and dissemination.

(6) Studying the barriers to GHG mitigation and response strategies and making programs to address barriers

During the implementation of priority GHG mitigation technologies, a series of problems concerning financing, policies, technology adaptation, personnel capabilities and so on will be identified. In order to address these problems, the government administrative department should coordinate, support and organize research activities among concerned organizations, and work out feasible measures and response strategies. TCF may provide help in this regard under the overall framework of China.

5.6.2 International Actions

International support can assist with implementation of priority GHG mitigation technologies by helping to find foreign donor funding and private sector partners, to share technology information, to assist with policy reform, to organize training programs and to establish information exchange channels. These actions are summarized below:

(1) Searching funding for projects. Identifying high priority projects among the selected priority technologies, and then providing assistance in preparing project proposals for the international donors.
(2) To organize technical consultation activities. Inviting international consultants and experts to provide advice on programs for overcoming technology implementation barriers.
(3) To organize and to support training program. Providing funds for organizing training programs and assisting with the training courses on GHG mitigation technologies.
(4) To support the establishment of an information service center. The tasks of this center are to remove obstacles owing to lack of information on the cost-effective of mitigation technologies. In addition, this center can also provide international organizations, investment organizations, foreign companies and individual with domestic market information and a more complete picture of China and GHG mitigation opportunities.
(5) Facilitating direct private investment in clean energy technologies through assistance in finding international business partners and business financies.

6. Conclusions

(1) In China a lot of technology measures can be adopted for mitigating GHG emissions, e.g. technologies for improving energy efficiency, using renewable energy and alternative energy. It is shown from research on technology priorities that many barriers will hinder the development of these GHG mitigation technologies. The TCF activities may be helpful to overcome those barriers, and implement UNFCCC provisions on technology transfer.

(2) Currently, the technologies considered in TCF are the development priorities and included in the corresponding government departments' plans. Some specific projects are already placed in national or department development plans. The next steps' work will focus on specific projects and serving donors and domestic funding. The TCF will also be integrated with China's "National

Communication" and "National Action Plans," that have not been available.

(3) For the projects involved in national or department development plans, funds will be provided by relevant departments. If these projects are selected in TCF activities, then supports from relevant departments will be guaranteed. All the five priority technologies mentioned above have corresponding projects to be supported by government. Therefore, the next step TCF activities will be ensured.

(4) Next Steps

(a) Further complete the organization of in-country team to guarantee the fulfillment of all TCF tasks. This may include establishment of implementation teams for each priority technology.
(b) Review existing market information for the priority technologies and conduct further market assessments to better define the specific, near-term opportunities for accelerating technology investment.
(c) Develop private investment programs for each priority technology that define actions that can be taken to directly stimulate private investment, including facilitating joint venture formation, business capacity building, and business financing support.
(d) Select several technology priority projects for implementing the private investment programs and removing market barriers, and prepare financing proposals to international investment organizations for these actions.
(e) Develop project proposals in accordance with general criteria for evaluating technology priorities and send them to international donors to search for finance support and matching donor support.

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Annex

- Detailed matrices are presented here for motors, boilers, and coal-bed methane technologies. These more detailed matrices are still under development for CFBC and wind power technologies.

Annex Table 1: Summary Matrix for Electric Motor Priority
Development benefits: Develops indigenous capability of energy efficiency motor production and improves energy efficiency of motor system
Total estimated CO2 reduction by 2005: 29 Mt
Total funding required: 150 million US$

Barriers	Foreign Action	Foreign Funding	Steps to Implementation	Domestic Action	Domestic Funding	Step to Implementation	Lead Agency	Private Sector Role
Weak competitiveness of energy efficiency motor and control system in market	Information & technology transferring, invest for energy efficient motor and control system	$ 35 million	Step 1 information exchange Step 2 Feasibility analysis on joint ventures Step 3 Investment in joint venture	regulating market, develop energy efficiency standards, increase capacity of energy efficient motor and system production	$ 65 million	Step 1 regulation, label and standards development Step 2 Policy and financial incentives for expanding energy efficient motor production and utilization	State Economic and Trade Commission (SETC)	Advise, invest
Lack of awareness on benefit of energy efficiency motor system	Information and experiences transferring	$ 4 million	Step 1 information and experiences exchange Step 2 assistance to build motor system clearinghouse	Increase awareness of opportunities and benefit of energy efficiency motor system	$ 6 million	Step 1 Best practice case studies, information and experiences dissemination Step 2 set up clearing house Step 3 training & education	SETC	Advise
Lack of capability for motor system retrofit	Information and experiences transferring, invest for motor system ESCos	$ 8 million	Step 1 information and experiences exchange Step 2 assistance and invest to set up motor system ESCos	Improve capability of motor system retrofit, incentives for retrofit activities,	$12 million	Step 1 training & education on motor system retrofit Step 2 incentive for retrofit activities Step 3 Develop motor system retrofit ESCos	SETC, China Energy Conservation Investment Corporation (CECIC)	Advise, invest in ESCos
Weak in motor repair service	Information and experiences transferring, invest for motor repair centers	$ 5	Step 1 information and experiences exchange Step 2 Invest on motor repair center	regulating market, set up standard for motor repair center	15 $ million	Step 1 Information and experiences dissemination Step 2 Policy and financial incentives for build up energy efficient motor repair centers	SETC, CECIC	Advise, invest in motor repair centers

Annex Table 2 : Summary Matrix for Advanced Industry Boiler (Increasing the Thermal Efficiency of Boiler)
Total estimated CO_2 reduction by 2010: 76 - 85 Mt
Total funding required by 2010: 35 ~ 44 billion US$

Barriers	Foreign Action	Foreign Funding	Steps to Implementation	Domestic Action	Domestic Funding	Steps to Implementation	Lead Agency	Private Sector Role
Lack of fund for renovation of old boilers · Lack of funds sources · How to reply loans with benefits	Search for foreign partners and investors Help to design repayment mechanisms for loans Assessment of renovation of plan and relevant measures	US$ 200 thousand	-Step 1: Help to design repayment mechanism for loans (US$ 100 thousand) -Step 2: Assessment (US$ 100 thousand)	Research and assess investment and repayment mechanism Research and formulate relevant policy and regulation	US$30 thousand	-Step 1: to search for way of investment and repayment mechanisms (US$ 15 thousand) -Step 2: project invest planning (US$ 15 thousand)	Resource Saving and comprehensive Utilization Department State Economic & Trade Commission, P.R.C or Local Economic & Trade Commission	Based on TCF project to search for way of fund advise: project invest
Do not establish mechanisms suitable Market economy to promote renovation boilers and spread high efficiency burning technology	Introduce foreign experiences Consult and cooperate in establishment of energy conservation service company	US$ 2.65 million	-Step 1: Introduce foreign experiences (US$ 150 thousand) -Step 2: Establishment of energy conservation service company (US$ 2.5 million)	Research and formulate relevant policy and regulations Set up a pilot of energy conservation service company	US$ 1.02 million	-Step 1: advise: formulate relevant policy and regulations (US$ 20 thousand) -Step 2: Set up a pilot projects of boiler renovation (US$ 1.0 million)	Resource Saving and Comprehensive Utilization Department State Economic & Trade Commission, P.R.C Local Economic & Trade Commission	Formulate invest policy and regulation with the implement of energy conservation law Develop the pilots of boiler project with the rational cooperation

(Annex Table 2, Continued)

Barriers	Foreign Action	Foreign Funding	Steps to Implementation	Domestic Action	Domestic Funding	Steps to Implementation	Lead Agency	Private Sector Role
Operation management of boilers is not good Fuels quality can not be guaranteed	introduce foreign experience for operation management and fuel supply mechanism	US$ 100 thousand	-Step 1: introduce foreign experience	Perfect the regulations for operation management for boilers Perfect coal markets and markets for other fuels	US$ 50 thousand	-Step 1: operation management for boilers (US$ 25 thousand) -Step 2: Perfect fuel markets (US$ 25 thousand)	Resource Saving and comprehensive Utilization Department State Economic & Trade Commission, P.R.C Local Economic & Trade Commission	implement relevant activities linking with projects
Persons for operation management and technical maintenance is not high level	Consult and help to implement training program	US$ 200 thousand	-Step 1: training program	Perfect relevant regulations and rules Organize training courses	US$ 100 thousand	-Step 1: Organize training courses (US$ 100 thousand)	Resource Saving and Comprehensive Utilization Department State Economic & Trade Commission, P.R.C Local Economic & Trade Commission	Search for international cooperation to organize training courses
Do not pay more attention to renovation of boilers Lack of relevant information	Consult and help in information and training	US$ 300 thousand	-Step 1: training	Enhance dissemination education and training Establish and improve information network	US$ 60 thousand	-Step 1: dissemination education (US$ 30 thousand) -Step 2: Establish and improve information network (US$ 30 thousand)	Resource Saving and Comprehensive Utilization Department State Economic & Trade Commission, P.R.C Local Economic & Trade Commission	Set up the information network Disseminate linking with TCF projects

Annex Table 3 : Summary Matrix for Coalbed Methane Utilization (Power Generation Using Gas Engine)
Development benefits: develops indigenous resources and reduces GHG emission
Total estimated CO_2 reduction by 2005: 0.56 Mt (by consuming CH_4 of 250 million m3)
Total funding required by 2005: 130 million US$

Barriers	Foreign Action	Foreign Funding	Steps to Implementation	Domestic Action	Domestic Funding	Steps to Implementation	Lead Agency	Private Sector Role
High capital investment and lack of credit	Providing soft loan or grants for CBM power plants	US$: 90 million	-Step 1: Demonstration -Step 2: Deployment	Provide matching funds and necessary facilities	US$: 36 million		State Economic & Trade Commission	Invest in project: Provide business planning advice
Lack of information and shortage of trained personnel	Provide technical training and technical instruction	US$: 1 million		Creating training programs for technical personnel	US$: 0.2 million		State Economic & Trade Commission	invest in project
Lack of local capacity to manufacture large size gas engine	Seeking foreign manufacturers for establishment of gas engine factories or joint ventures locally	US$: 0.6 million		Identifying local investors and expedite approval of new business or joint ventures	US$: 0.4 million		State Economic & Trade Commission	advice
Low electricity price to local power grid for CBM power plants	Technical assistance in getting power purchase agreement with good price	US$: 0.6 million		Use the electricity on site instead of purchasing electricity or directly supply to end users	US$:		State Economic & Trade Commission	provide information
Awareness of environmental benefits of CBM power plant for local air pollution	Providing data and methods for evaluating environmental benefits of CBM power plant	US$: 0.3 million		Disseminating materials to local government and promote consideration of gas engine as an alternative to conventional energy sources	US$: 0.2 million		State Economic & Trade Commission	