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Fighting climate change:
Human solidarity in a divided world

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OCCASIONAL PAPER

Mitigation Country Study – China

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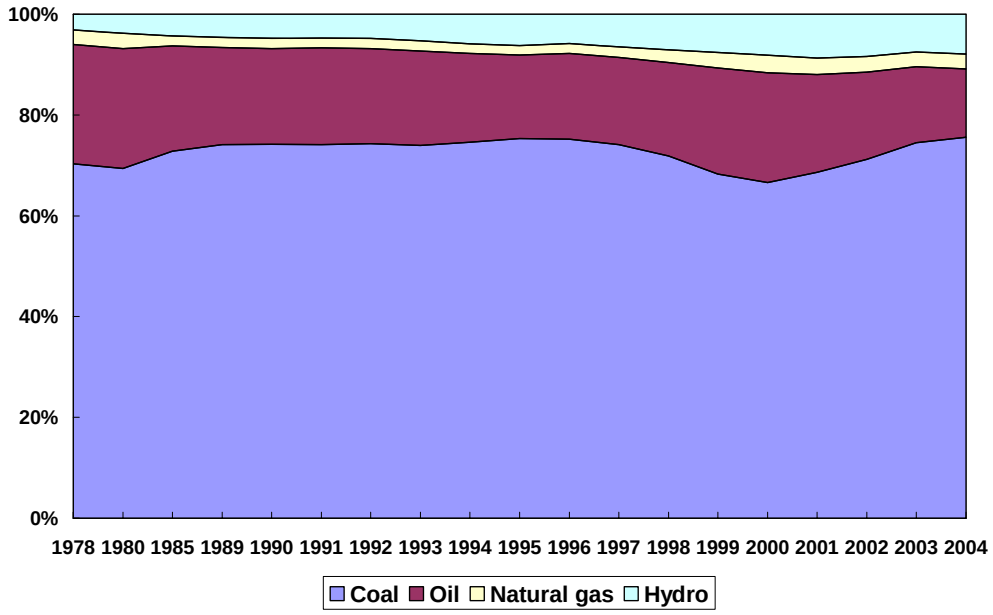
1 Energy profile and trends in China

Because of rapid economy growth, total primary energy consumption increased from 400Mt-Ce in 1978 to 1970 Mt-Ce in 2004, with an annual average rate 5% (see figure 1). Coal is the major energy in all energy use, taking share of 70.7 in 1978 and 67% in 2004 in total primary energy use (see figure 2).

Figure 1. Energy production in China



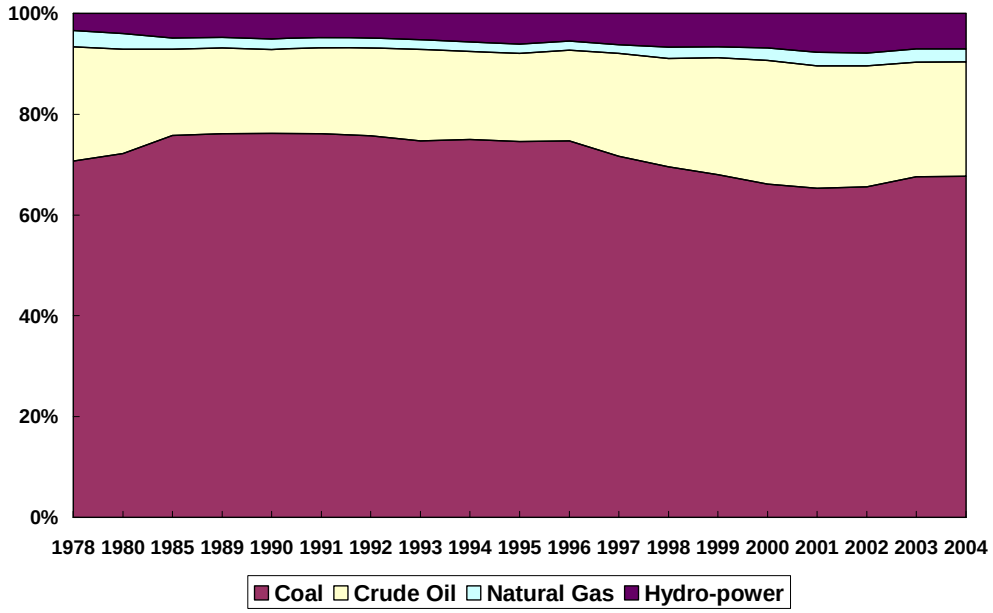
Source: 2005 China Statistical Yearbook & 2005 China Energy Statistical Yearbook

China is the largest coal producing and consuming country of the world. Between 1980 and 2004, total raw coal output increased from 620 Mt to 1970 Mt, the average annual growth rate is 5%. China's coal consumption accounts for 29.6% of the world total in 2000. Coal plays an important role in the development in China. It is not only the main fuel of industrial sectors, but also important residential energy and chemical feedstock. In China, coal is mainly used as electricity generation, heating supply, cooking, residential living, chemical industry, building material etc.

From 1980 to 2004, total installed capacity increased from 66 GW (of which hydropower is 20 GW, accounting for 31%) to 420 GW (of which hydropower is 110 GW, accounting for 25%). In the same period, electricity output increased from 300 TWh (of which hydropower is 58 TWh, accounting for 19%) to 220 TWh (of which hydropower is 310 TWh, accounting for 17%). During this period, both the average

growth rate of installed capacity and electricity consumption reached as high as 8.3% per year. The major consumers are industry, residential living, agriculture, commerce, transportation and communication, and construction, in 2004, their shares were 74%, 11%, 4%, 2%, 2% and 1% respectively.

Figure 2. Primary energy use in China by energy



Source: 2005 China Statistical Yearbook & 2005 China Energy Statistical Yearbook

The electricity industry made a considerable achievement in energy conservation. During the 1985-2004 period, specific coal consumption for electricity supply and for electricity generation decreased from 431 gce/KWh and 398 gce/KWh to 380 gce/KWh and 360 gce/KWh.

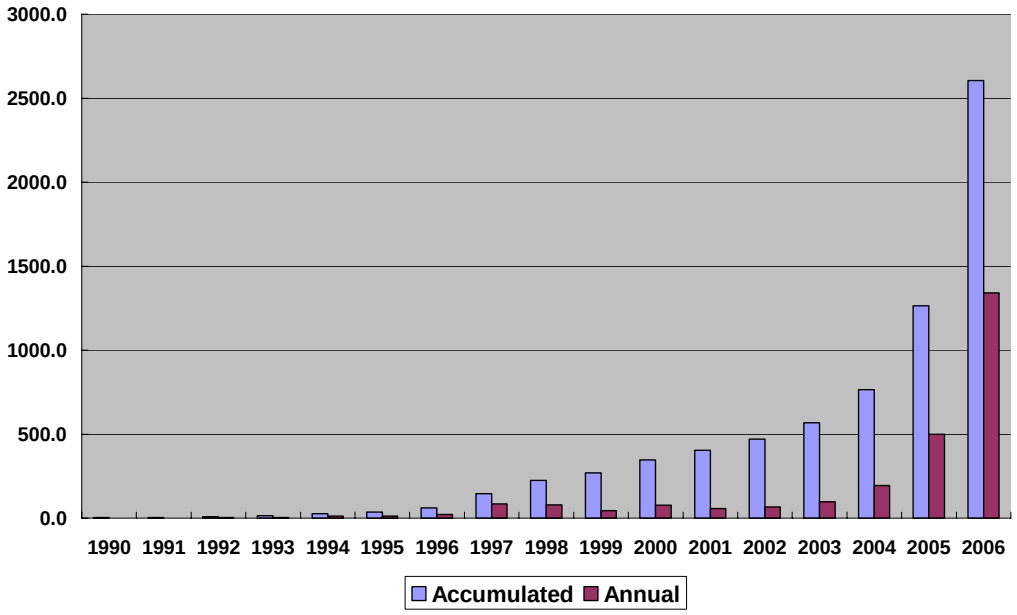
China's nuclear power industry is at the beginning stage, at present, there are 3 units that are operating. The total installed capacity is 2100 MW. One of the three units is in Qinshan Nuclear Power Station (first stage), which capacity is 300 MW, and the other two are in Dayawan Nuclear Power Station, which capacity is 900 MW each. In 2004, nuclear electricity output is 14.2 TWh. There are 8 units with total capacity of 6600 MW which are ongoing constructing.

Between 1980 and 2004, total crude oil output increased from 106 Mt to 167 Mt (average annual growth rate is 2.1%). Of the total oil output in 2004, 149 Mt is produced in land, and the rest 18 Mt is produced in offshore. Crude oil output in China accounts for 4.7% of the world total.

In 2004, total natural gas output in China is 33 billion m^3. Total natural gas final consumption is 27 billion m^3, of which 6.00 billion m^3 is used for producing chemical fertilizer and other chemical products, 14.5 billion m^3, is used as industrial fuel and 5.2 billion m^3 is used for urban residential uses.

Two-thirds of China's energy is now supplied by coal, which when burned releases sulfur and particulates causing severe air pollution problems. Coal use, of course, releases twice as much carbon dioxide per unit of energy than gas combustion. China has abundant coal resources and has for a long time used this fuel to provide the bulk of the nation's energy needs. But in order to take advantage of cleaner-burning, more efficient fuels, China is reducing coal's dominant position by increasing the share of natural gas, oil, hydropower, nuclear power, and renewable energy. The current five-year plan sets goals of improving the energy infrastructure, increasing the share of energy provided by natural gas, and reducing coal use through various measures. This shift will directly reduce greenhouse gas emissions, compared to using coal to provide the same amount of energy.

Figure 3. Wind Development Review in China (MW)



Source: Li Junfeng & others, China Renewable Energy Status Review, China Power, 2006, Volume 12.

The use of renewable energy resources plays a strategic role in maintaining balance between energy supply and demand in China; and the Chinese Government has therefore consistently promoted the development of renewable energy. China enjoys very rich renewable energy resources. At present, traditional, non-commercial renewable energies (e.g. fuel wood) provide China with energy of over 210 million tons of standard oil equivalent (toe) annually. Small hydropower installations provide

about 100 billion kilowatt hours (kWh) of power annually, accounting for five percent of China's total electricity output. Adding in other renewable resource applications, China's total annual use of renewable surpasses 12,000 Petajoules (PJ), accounting for 15% of the nation's total energy use. And the commercial based renewable energy took only about 7.5% of the total national energy use. After the Renewable Energy Law to be effectiveness on January 1 of 2006, all the redeemable energies have been developed very fast. Such as the wind, it was doubled in 2006 compare with 2005. See Figure 3.

2 Current emission status & trend

2.1 National greenhouse gas inventory

The National Greenhouse Gas Inventory for China in the year 1994 includes estimated net anthropogenic GHG emissions from the energy sector, industrial processes, agriculture, land-use change and forestry, and wastes, and reports on emissions of such gases as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

The energy activities inventory mainly covers emissions of CO_2 and N_2O from the combustion of fossil fuels, emissions of CH_4 from coal mining and post- mining activities, fugitive emissions of CH_4 from oil and natural gas systems, and emissions of CH_4 from the burning of biomass fuels. The industrial processes inventory includes emissions of CO_2 in the production processes of cement, lime, iron and steel, and calcium carbide, as well as emissions of N_2O in the production process of adipic acid. The agricultural activities inventory covers emissions of CH_4 from flooded rice paddy fields, animal enteric fermentation and manure management as well as emissions of N_2O from croplands and animal waste management. The land-use change and forestry activities inventory mainly covers changes in the stocks of forests and other ligneous plants as well as emissions of CO_2 due to the conversion of forests to non-forest land. The waste treatment inventory mainly covers emissions of CH_4 from treating municipal solid waste and that from treating municipal domestic sewage and industrial wastewater.

The 1994 Inventory has been prepared with methods provided by the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and using IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories as a reference. The inventory agencies established the technical approaches for developing the 1994 National Inventory on the basis of defining China's sources of emissions, ascertaining the key sources of emissions, the availability of activity data and emission factors and analyzing the applicability of the IPCC methodologies.

According to the estimated results, China's total net emissions in 1994 are: CO_2, 2666 million tons (728 million tons of carbon equivalent), among which emissions from energy activities amount to 2795 million tons and emissions from industrial processes amount to 278 million tons whilst emission removals by sinks from land-use change and the forestry sector amount to 407 million tons; CH_4, 34. 29 million tons, among which emissions from agricultural activities amount to 17.2 million tons, emissions from energy activities amount to 9.37 million tons and emissions from waste treatment amount to 7.72 million tons; N_2O, 850,000 tons, among which emissions from agricultural activities amount to 786,000 tons, emissions from industrial processes amount to 15,000 tons and emissions from the energy sector amount to 50,000 tons. Calculated according to the Global Warming Potential (GWP) values provided by the IPCC's Second Assessment Report, China's total GHG emissions in 1994 was 3650 million tons of CO_2 equivalent, with CO_2, CH_4 and N_2O contributing to 73.05%, 19.73% and 7.22% of the emissions respectively.

2.2 GHG emissions change trend

With the rapid economic growth, environment problems have occurred in many cities and regions. Air pollution, water pollution, soil degradation etc. are the most serious problem in China. Because of large amount coal use, China is the largest emitter of SO_2. More then eleven provinces suffered acid rain damages.

China has begun to make environmental protection a policy priority. Sustainability has become a key concept for Chinese government, and the government has formulated policies and measures toward goals of sustainable development.

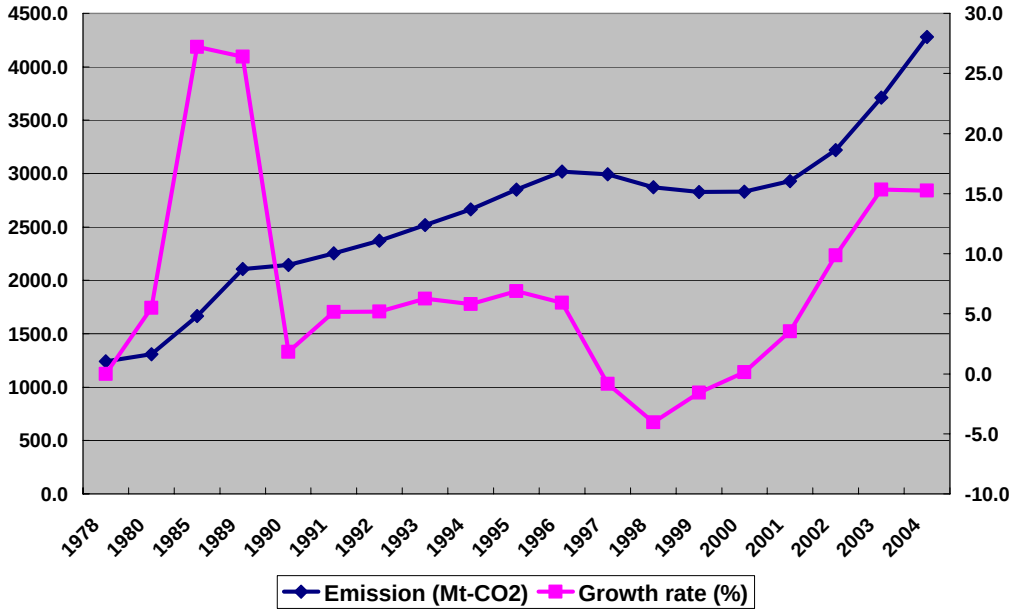
China has also increased its attention to matters directly related to climate change. The government established the inter-ministerial National Climate Change Policy Coordinating Committee in 1990, making it responsible for policies and measures to address climate change. China signed and ratified the United Nations Framework Convention on Climate Change in 1992, and ratified the Kyoto Protocol. The government has cooperated with other governments and multilateral organizations in a number of international programs in the broad field of climate change. For example, there have been five "joint implementation" projects conducted in cooperation with Japan, Norway, and the United States.

China ranks second among nations in greenhouse gas emissions, mainly as a result of fossil fuel combustion. This fact is mainly comes from the context of China's large population, which is more than four times that of the United States, the world's largest emitter. Chinese decisions nevertheless profoundly affect global emissions growth, and these decisions are, as elsewhere, driven by trends in economic development, local environmental protection, and technological change. Development policy in China has reduced its emissions growth well below expected levels, however, and a convergence of environmental issues with development imperatives offers an ongoing

if uncertain opportunity to continue to slow emissions growth.

By using IPCC emission factors and some revised emission factors in China, CO_2 emission in energy sector was calculated and is shown in figure 4.

Figure 4. CO_2 Emission through energy use



Source: Calculated based on the energy use and emission factor of IPCC

The trend of Carbon emission from energy sectors was as following: Before 1980, the carbon emission growth rate was above 10%, in average; During 1981 to 2002, due to the energy conservation, the carbon growth rate was 5% or below; Especially during 1987 to 2001, the emission growth rate even below than 5%; However, after 2002, the emission growth rate in higher than 5%, especially in year 2003 and 2004, the emission growth rate as high as was 15%. In the year 2005, Chinese government recognized the serious situation of energy consumption growth, a 20% reduction of GDP energy use had been proposed and the energy growth rate in 2006 became to slower than it was in 2003 and 2004.

3 Projection of carbon emission

3.1 Development projection in China

In 2005, new economic development targets have been made by Chinese government through the national development strategy and planning. It was planned to be quadrupled of the GDP of the year 2000 by 2020, with a well-off society in an

all-round way. It is first time sustainable development appeared in the documents of Chinese government.

Studies for population growth in China suggested it will be around 1500 million by 2030. Scenario assumption for population from selected studies is shown in table 1.

Table 1. Population projection in China (million)

	1990	2000	2010	2020	2030
Population in IPAC	1141	1284	1393	1472	1539
Urban population in IPAC	302	413	531	633	754
Rural population in IPAC	840	872	862	839	785
Population from CASS	1141	1330	1480	1518	1550
Urban	302	500		735	870
Rural	840	830		783	680
Population from Chen Xi Kang: Medium Case	1141	1282	1400	1500	1560
High Case	1141	1297	1420	1530	1595
Low Case	1141	1276	1380	1470	1520
Population from ERI	1141	1304	1415	1496	1558

Source: Low carbon emission energy scenarios analysis, ERI publications, 2003

For the GDP development trend presented, there are various studies by many institutions, such as ERI, IEA and other. All studies show GDP growth in will keep fast for next several decades. Basic trend follows government targets, which aimed GDP per capita will reach the level of OECD countries at beginning of 1990s by 2050. And more recently in the beginning of this year, Chinese government announced economy development goal by 2020 as four time of GDP compared with that in 2000. That means the average GDP growth rate will be 7.18% for next twenty years, giving China one of the rapidest countries in the world.

3.2 Energy demand projection in China

China is a developing country so that economic development is its first objective. Various forecasts show that in the future time of period, the economy will continue to grow. The ERI analysis shows that by 2020, when the overall well-off society is realized through structure optimization and benefit improvement, the GDP will reach 4300 billion US$ with the annual growth rate averaged at 7.2% and the per capita GDP will reach or exceed 3000 US$. At that time, the overall national power and international competitiveness will grow significantly, industrialization will be achieved and the share of city and township population will increase greatly.

In the meantime, China is still in the process of industrialization thus the industry is playing a key role in the economic development. The high-input and high output growth pattern will sustain for a certain period of time. Although in the past, present and future, energy conservation has always been the focus of the national government which strongly promote energy saving and efficiency improvement, energy demand will grow inevitably. When in 2020 the GDP quadruples compare to the 2000 level, the iron and steel, non-ferrous industry, petrochemical, chemical and cement industry will accelerate; automobiles and household electric appliances will flood into households as the result of improvement of living standards; the urbanization will progress rapidly and energy use for buildings and domestic purposes will grow considerably. Based on the energy consumption growth pattern for the past three years, by 2020, the annual energy demand will be as high as 4 billion tce. The huge demand will impose serious problems on coal, oil and electricity supply as well as energy security. Based on the energy mid and long term development plan which takes fully into account energy saving, by 2020, energy consumption will still reach 3 billion tce. The per capita energy consumption will be around 2 tce, close to the world average per capita level then.

There are several energy scenario studies in China. However, there is now official public energy projection available and the follow results are only the projection calculated by the authors. The two scenarios are defined as follows:

- Baseline scenario: This scenario gives a basic trend to describe future economic activities. There will be better international trading and China's economy will be part of global economy. Therefore China could rely on international markets and energy resource imports to meet part of its energy supply needs. Primary energy demand in the baseline scenario could go to 3 billion tce in 2010 and 4 billion tce in 2020 in the baseline scenarios.
- High efficiency demand scenario: This scenario presents a high efficiency demand for energy in the future. The major driving force is China's 20% reduction of per GDP energy use regulation, which indicated that by 2010, the per GDP energy use will be reduced 20% compared with the level of 2005. Base on this assumption, the primary energy demand in the baseline scenario could go to 2.8 billion tce in 2010 and 3.4 billion tce in 2020. As the contrast, the total energy use reduction in high efficiency scenario will be 200 and 400 million toe respectively in 2010 and 2020, compared with the baseline scenario.

3.3 General projection of carbon emission in China

Besides the high efficiency programs, Chinese government has also launched a renewable energy development program and indicated that the renewable energy use rate will be increased from 7.5% in 2005 to 10% in 2020 and 16% in 2020 respectively. The two policies will be the major driving force for the reduction of carbon emission in

China. The total carbon emission in 2010 and 2020 will be about 5930 and 6757 million ton of CO_2 by 2010 and 2020 respectively.

3.4 Carbon emission projection by sectors

3.4.1 Sector analysis of emission reduction

China is in the period of industrial development, the resource consumption proportion of the second industry reach to 50%, compared with 30% of those in developed countries and 34.7% of world average. Nowadays, China is with highest energy consumption per average GDP, which is higher than those in developed countries and at the same time, higher than those in developing countries though they are with the same average GDP as China. The status of China is with low energy efficiency, laggard whole economic and technical level, and unit energy consumption of main industrial products is 140% of those in developed countries. Meanwhile, compared to developed countries, Chinese energy exploitation efficiency is 30% less, energy process and transform efficiency is 5%, terminal energy efficiency is 10% less than those in developed countries. Therefore, energy conservation, energy efficiency improvement and renewable energy development become the main technical measurements to achieve the target of emission reduction.

Electric power department, industry department and transport department are the main departments to reduce emission in the next several years of China. In the next 20 years, the technical potential of emission reduction in these departments will be approximately 70% of whole technical potential. Compared with traditional technology, adopting advanced technology and low carbon emission technology will be with great potential to reduce CO_2 emission. However, in order to achieve these technical potentials, it is needed to pay huge efforts and to overcome several barriers from technology, economy, politics, culture, society, behavior and (or) system.

3.4.2 Electricity power sector

With the high-speed development of economy, electric power demand of China has grown rapidly in the past 20 years. By the end of 2005, total installation capacity reached to 0.52 billion KW. Because coal will conduct electric power and thermal power generation in the future, it is obviously that this department will be the main department to reduce emission. The target not only reducing emission but also improving environment, will be reached by adjusting system stature, improving efficiency of generator and utilizing new, clean and high efficiency technologies, such as CFBC, IGCC, PFBC, APFBC and GTCC. Up to 2020, total installation capacity of coal generator will reach to 600 GW from 330 GW 2005. Unit coal consumption will decline 18.8%, from 392 gce/kWh in 2005 to 320 gce/kWh in 2020. Compared with 2000, in 2020, the potential CO_2 emission reduction of coal generator will be 0.15 billion t-C.

3.4.3 Industry sector

Industry department is one of main energy consumption department of China with energy consumption in 2005 of 1.4 billion tce, where the energy consumption of chemical, iron and steel, and building materials was 0.8 billion tce, amounting to over 50% of total energy consumption of industry department. Though unit energy consumption is declined obviously in recent years, there is a big gap compared with international advanced level.

In the past many years, because coal consumption is the main part of Chinese energy structure, the whole energy industry system lagged international level. From 1980s, industry facilities increased rapidly. Except for some facilities with advanced international technical level of 1980s, most of them were with technology out of date, which, therefore, caused lower energy efficiency than energy efficiency in developed countries. Hence, the main strategy of CO_2 emission reduction is to increase the utilization efficiency of energy and its raw materials, to import advanced manufacture processing and technologies, to improve energy consumption structure, and to recycle CO_2 and other useful gas from waste gas. According to result from national R&D institute, up to 2020, whole industry energy conservation of China will be 0.6 billion tec, which equal to reduce 0.39 billion t-C of emission.

3.4.4 Transport sector

The increasing energy demand of transport department of China will keep a high speed and will impact whole national energy demand and environment protection issue. The reasons are continuous increase of Chinese economy, speedup transform trend from rural area to township and city, improvement of resident income and living quality, and speedup trend of private car. In the period of 2000 to 2004, the amount of Chinese automobile has increased with the annual rate of 11%. Meanwhile, private car’s annual increasing rate is 22%. It is predicted that the amount of Chinese automobile will keep increase in the next several decades.

In 2005, crude oil import of China exceeded to 0.1 billion ton and reached to 0.12 billion ton, which increased 34.8% compared with the amount of 2003. Besides import crude oil in 2004, China also imported 37.88 million tons of other petroleum products, which increased 34.1% compared with the amount of 2003. It is predicted that, up to 2020, petroleum demands of China will reach to 0.6 billion ton, however, domestic supply will be no more than 0.2 billion ton. Therefore, 60% of petroleum will depend on import. As same as building materials, in 2020, transport department will become one of main priority emission reduction field and main green-house gas emission factor.

Because road transport is main consumption part of transport sector, there are two

measurements to reduce green-house gas emission. One is to improve engine technologies therefore to increase energy efficiency and conserve energy. The other is to use substitute fuel such as natural gas, liquefied petroleum gas, and electric motor, therefore to reduce the dependence on petroleum. According to the research results from national R&D institute, in 2020, compared with 2000, its CO_2 emission reduction potential will be more than 40 million t-C.

3.4.5 Building sector

Average housing area per person can indicate the economic development level of its country. It is shown from experiences all over the world, when the average GDP per person reach to $800, the building industry will come into the period of rapid development. Before reaching 30 to 35 m2 per person, this demand will keep for a long time. In 2004, average GDP per person of China exceeded to $1000, and the development of building industry is on the way of a blooming period. According to the forecast from the World Bank, at the year of 2020, 70% of the amount of Chinese civil buildings will be built after 2000.

Some building energy consumption facilities, such as heating, air conditioning, lighting, hot water and home appliances, will increase rapidly in the future. The reasons are the increase of building area, the improvement of civil living conditions and civil housing, the increased use of home appliances such as heating and air conditioning, and the increased demand for a comfortable indoor environment. Besides, with the development of the third industry, the amount and energy consumption of those apart from civil buildings will increase continuously. It is shown from the information of building department, in 2003, energy consumption related to buildings reached 0.376 billion tce which occupied 31% of the whole terminal energy consumption of China. This figure was near to that in developed countries. In all building area, 60% are for living, in which 75% energy consumption is from heating, air condition and lighting. Therefore, building department has become a new energy consumption and high quality energy demand department.

In 2005, person average living area is 27 m^2, which is 45-60 m^2 in developed countries. According to the research of the building department, the living target of a overall welfare society is 35 m2 per person. Therefore, up to 2020, the living area of whole China will reach to 50 billion m2. If the present building energy consumption will be kept, in the year of 2020, the total building energy consumption will exceed to 0.8 billion tce, which is the whole terminal energy consumption of China in 2000. Therefore, it is obviously that building department will become one of the prior department to green-house gas emission resource and emission reduction.

The development targets for future building energy technology are to utilize advance energy service technologies and to invest environment protection with low costs. It is shown in IPCC research, there are more than 200 new technologies and energy

conservation technologies can be used in the building department. Most of them have been commercialized, though they are not used properly. Some of latest technologies include building complex design, PV building integration system, building distributing generation system and traditional energy utilization technologies, such as cooking, heating appliance and other home appliance. High efficiency, clean heating technology, solar thermal utilization and biogas technologies are main trend in the future. The utilization of these technologies will reduce emission. According to the research from relevant R&D institute, compared with 2000, in 2020, the CO_2 emission reduction potential will exceed to 0.1 billion t-C.

3.4.6 Summary

The targets will be reached by taking above measures. The detailed targets are: in the year of 2010, the energy consumption of GDP per 10000 Yuan will decrease to 2.25 tec from 2.68 tec in 2002. From 2003 to 2010, annual energy conservation rate will be 2.2%, which will save 0.4 billion tec. In the year of 2020, the energy consumption of GDP per 10000 Yuan will reduce to 1.54 tec. From 2003 to 2010, annual energy conservation rate will be 3%, which will save 1.4 billion tec, equaling to 111% of the planning energy generation increment (1.26 tec) of this period. 21 million ton CO_2 emission will be reduced. In the year of 2020, 0.7 billion ton carbon equivalent will be reduced this year. Industry is the major energy consumer is China and total energy use in industrial sector takes about 70% and the energy use in transportation sector currently is relatively small and it took only about 7.5% in 2004 and the residential & other takes about 25%. However, based on the industrial structure changes, the energy use by sectors will be changed to about 56% of industry, 15% of transportation and 29% of residential and others. Therefore, the emission by sectors will calculated based on total energy use and energy structures.

4 Government policy for reducing the carbon intensity of growth and overall carbon emissions

4.1 Issues and challenges of development in China

China is the most populist country in the world with fragile ecological environment, significant climate variation and vulnerable to the adverse effect on climate change. The coal dominant energy structure, urbanization, industrialization and improvement of people's living standards will cause GHG emissions continue to grow. China has faced unprecedented serious challenges which are:

1) Pressure on China to limit its GHG emissions from developed countries is intensified. After the Kyoto conference, some developed countries argued that the Kyoto Protocol sets reduction targets from developing countries, therefore demanding actions from major developing countries such as China and India. The US even clearly positioned that developing countries' participation is one of their conditions for

ratifying KP and should be linked to financial mechanisms under the Convention.

2) Challenge to the existing development and consumption patterns. The conventional consumption and production pattern in China is resource intensive and unsustainable and impose threat on social and economic development. Although each country has the choice of development path, there is no exception in the world about the law of development process. The history and trend in every country in the world show that there is a clear link between per capita commercial energy consumption and the level of economic development. The current technology level and consumption pattern can only allow high per capita energy consumption level in order to achieve the development of industrialized countries. There is no precedent in the world until now that high per capita GDP level can be supported by low per capita energy consumption. Hence, it is a great challenge for China to explore a new sustainable consumption and production path.

3) Challenge to the existing coal dominant energy structure. China is one of the few countries in the world that relies on coal which accounts fro 67% of national primary energy consumption. Compared to oil and gas, the per unit heat value CO_2 emissions of coal is 36% and 61% higher respectively. On the other hand, energy structure improvement is dependent on energy resources and energy use efficiency improvement is constrained by technology and capital availability. The existing energy resource and consumption structure impose significant challenge on CO_2 emission control in China.

4) Ecological environment is vulnerable and susceptible to adverse effects of climate change which challenge the adaptation to climate change. It is observed that the effects of climate change on China are: sea level increase, reduction of glacial in the northwest, the decrease of tundra in Tibet, early spring, the expansion of drought area in the north, more floods in the south and bleaching of coral reefs. The future climate change will continue to affect the natural ecological system as well as social and economic development. The most significant effects are on agriculture and husbandry production, forestry and grassland, water resources and coastal environment and ecological systems, characterized by negative effects of which some are irreversible.

4.2 Sustainable development related national policy

In order to address the above-mentioned conflicts, the national government has adopted three measures in energy field, namely enhanced energy conservation that result in significant improvement of utilization efficiency of energy and various resources; use international resources such as oil and natural gas and acceleration of renewable energy development. To realize these measures, a series of laws, regulations and policies have been formulated which contain the following that are most relevant to sustainable development and climate change.

1) A science directed development path is adopted and resource conservation and environmentally friendly society shall be established: The economic growth pattern shall be changed quickly. The national policy stated that resource conservation is the basis, a circular economy should be pursued, ecological environment should be protected, harmonious development between economy, population, resource and environment shall be promoted in order to establish a resource conservation and environmentally friendly society. A new type of industrialization process shall be consolidated and development shall focus on conservation, clean, security and sustainability.

2) Formulate and complete various laws and regulations in order to promote energy conservation and renewable energy development: In 1998 and 2005, the government promulgated the Energy Conservation Law of PRC and Renewable Energy Law of PRC respectively. The two laws provide legitimacy of energy conservation and renewable energy development in the country. At present, the government is considering the formulation of Energy Law and amending Energy Conservation Law and Electric Power Law. These activities will benefit energy conservation and renewable energy development.

3) Government planning that directs companies and the entire society to conserve energy, increase energy efficiency and develop renewable energy: In 2004, the national government promulgated the Energy Conservation Mid and Long Term Plan with the targets for 2010 and 2020. At present the government is formulating the Renewable Energy Mid and Long Term Plan which will put forward the objectives and measures of developing renewable energy in 2010 and 2020. A target of 10% and 16% of renewable energy will be deployed in China by 2010 and 2020 respectively. The recently published the Outline of Tenth Five-Year-Plan for National Economic and Social Development for the first time included the targets such as “the energy use per GDP shall decrease 20%”, “encourage the production and consumption of renewable energy of which share in the primary energy consumption shall be increased”. These provisions will consolidate the implementation of energy conservation law and renewable energy law.

4) Build new villages and close the gap between urban and rural areas as well poor and rich: The state will implement an integrated social and economic development in urban and rural areas as the basic strategy. In the course of urbanization, the new rural society shall be promoted characterized by production and development, well-off living, rural civilization, tidy environment and democratic management. There are special requirements on energy saving and renewable energy with regard to the building of new villages such as conserve land use, energy saving and environmental protection, sound rural and village planning. House building shall be guided by the principle that traditional style shall be preserved, while biogas, straw for power generation, small hydro, solar power and wind power shall be promoted actively.

5) Develop regional and global cooperation program for clean energy: Currently, China is the member of APP (Asian and Pacific Clean Development Partnership), member of GBEP (Global Biomass Energy Partnership) and member of IPHE (International partnership of Hydrogen Energy) and others. Especially, Chinese government already spent about 2 billion Chinese Yuan for hydrogen energy and other related programs. 4 fuel-cell buses have been running in Beijing and Shanghai. China is also interested in the international cooperation of carbon sequestration.

6) China ratified the Kyoto Protocol in 2002 and it is one of the largest CREs sales in the world. Currently about 300 projects of CDM have got the letter of approval (LOA) and more then 40 projects have been successful got the registration in the EB of UNFCCC. The total CERs is around about 100 million tons CO_2.

5 Financial and technological constraints restricting

5.1 Technical and financial risks of decarburization

The technical and financial risks of decarburization in different technologies are quiet different. Here is the detailed analysis of the technical and financial risks for the major technologies for the carbon reduction.

5.1.1 Renewable energy

Renewable energy utilization plays an important role in balancing Chinese energy supply and demand. Chinese government's attitude towards RE is quite positive and supportive. Currently, the total amount of traditional renewable energy utilization is more than 0.3 billion tce. Small-hydro power capacity is about 100 billion KWh, which accounts for 5% of the total electric power capacity in China. Taking into consideration of the new renewable technology, the total renewable energy utilization will exceed 12000 PJ, equivalent to15% in Chinese energy structure. Emission reduction potential from renewable energy sector goes as follow:

1) Wind power

With vast territory and extended coastline, China is a country with abundant of wind energy resource. According to the assessment from China Meteorology Science Research Institute, available terrestrial wind power is about 253 GW (10 m above ground). And available offshore power is about 750 GW. Total available wind power of China is 1 billion kW. Among all the renewable energies, wind power generation is the one that is most commercialized and could be utilized in large scale in the near future.

According to National Renewable Energy Development Plan, by 2010 and 2020, wind power installation capacity will reach 5 GW and 30 GW respectively. This ten-year period will act as a transition period for the wind power industry to take off to

large-scale application. It's expected that the installation capacity will reach 0.15-0.2 billion kW by 2030 and wind power will be the third largest power source in China. The CO_2 emission reduction potential of wind power by 2020 is 16 Mt-C.

2) Small-hydro power

According to the latest hydro resource survey, the available utilization capacity is 125 million kW, scattering in nearly 1600 counties (cities) in 30 provinces of China. According to the National Renewable Energy Development Plan, by the year 2010 and 2020, the total installation capacity of small hydropower will reach 50 GW and 75 GW with power generation of 165 billion kWh and 250 TWh respectively. The CO_2 emission reduction potential of small hydropower by 2020 is 60 Mt-C.

3) Biomass

Chinese biomass resource comes mainly from agriculture waste, wood and forest residuals, and municipal waste. The total available resources are about 0.1 billion tce. According to the National Renewable Energy Development, by the year of 2010 and 2020, the total power installation will reach 5.5 million kW and 20 GW with power generation of 20 TWh and 80 GWh respectively. Meanwhile, biogas utilization will reach 20 billion m3 and Liquid Bio-fuel is predicted to replace 10 million tons of petroleum by 2020. The total CO_2 emission reduction potential of biomass utilization by 2020 is 85 Mt-C.

4) Solar energy

China has extremely rich solar energy resources. According to estimates, the total solar radiation hitting China's land area annually is 5×10^{19} kilojoules (1.2×10^{19} kilocalories), equivalent to about 1700 billion tons of standard coal equivalent (tce). Based on the distribution of the total radiation hitting China's land surface, it can be seen that Tibet, Qinghai, Xinjiang, the southern part of Inner Mongolia, Shanxi, northern Shaanxi, Hebei, Shandong, Liaoning, western Jilin, the middle and southwest parts of Yunnan, the southeastern part of Guangdong, the southeastern parts of Fujian, the eastern and western parts of Hainan, and the southwest part of Taiwan all receive a relatively large amount of solar radiation. In particular, areas on the Qinghai-Tibetan Plateau receive the largest amounts of solar radiation in all of China.

There are two major technologies for solar energy use in the world, one is solar thermal and the other is the solar power. Currently, the main use of solar energy in China is the supply of hot water to urban and rural areas. Solar water heater in one of renewable technologies those are in commercialisation stage in China. China is with the largest solar water heater market in the world and the industry is also in the first site. The accumulated installed capacity of solar water heaters by the end of 2006

was 100 million square meters of collect area, with an annual increase rate of 27% in the passed ten years. At present, about 8% families are with solar water heater systems. The production capacity of solar water heater in China is 12 million square meters at present, with an annual increase rate of 28% in ten years since 1995. There are over 1000 enterprises and the employees are over 150,000. Presently the issues associated with integration of solar water heaters into buildings have already attracted strong attention from relevant national-level and local government departments, architects and real estate developers, and solar water heater integrated building is the developing trend in this field. In 2010, it is expected that the installation areas of solar collector will be 140 million square meters. In 2020 and 2050 total installed capacity can reach 270 million and 500 million square meters, respectively, with the potential to conserve 120 TWh in 2020 and 300 TWh in 2050. Potential reductions in peak power loads resulting from these installed capacities will be 80 GW (2020) and 200 GW (2050), and the carbon emission reduction will be 29 million tons (2020) and 72 million tons (2050).

Solar PV is the major power generation technology of solar in China. PV modules are used in both industrial and commercial applications and provide electricity to remote rural areas and urban lighting applications. By end of 2006, China's installed capacity of PV systems in over 100 MW, of which about 50% is used to supply electricity to the residents of remote rural areas, a market that is growing at 20% annually. From 2002 to 2004, China implemented a project of Songdiandaoxiang (renewable village power), and PV systems with capacity of 17MW were installed. At present, apart from the independent PV systems in remote areas without accessing power gird, China began the demonstration of roof grid-connected PV systems, and has gotten technical and engineering experiences. The industrial and commercial PV markets are also relatively stable. China's annual production capacity for urban PV lighting systems is over 10 MW, accounting for 70% of the world total. In the year 2005 and 2006, around 8 solar PV manufactures are listed in the world stock markets, include New York and Londun and the total annual PV production capacity is around 1500 MW and the real production is around 300 MW, which takes about 15% of the world total.

The carbon reduction from solar will be mainly relied on solar thermal before 2020. 2010, it is expected that the total area of installed solar collectors will be 140 million m^2. In 2020 and 2050, total installed capacity may reach 270 million and 500 million m^2, respectively, with the potential to conserve 120 TWh and 300 TWh of electricity. Potential reductions in peak power loads resulting from these installed capacities could be 80 GW and 200 GW, respectively, with carbon emission reductions of 29 million tonnes and 72 million tonnes in those years.

5) Other renewable energy

Besides large-scale utilization of biomass, wind power, solar power and small hydropower, Chinese government also pays attention to geothermal, ocean energy

and hydrogen energy technologies. Several pilot projects and demonstrations in geothermal power generation, wave power generation and geothermal heating and cooling have been implemented. Geothermal pumping technology, in particular, has already begun to play a significant role in building sector in China.

However, up to now only solar thermal utilization can produce a substantial amount of carbon emission reduction. By 2020 and 2050, solar heater will replace power generation of 120 billion kWh and 300 billion respectively. The total CO_2 emission reduction potential of solar heater by 2020 is 79 Mt-C.

As the conclusion, the proportion of total renewable energy utilization is expected to reach 10% in the total energy mix by 2010, and16% by 2020, With this development capacity, The total amount of CO_2 emission reduction contribution from renewable energy by 2020 will be 270 Mt-C.

The challenges and barriers for promoting renewable energy development are:

- Lack of consistent policy system to encourage long-term development of renewable energy. Current policies and laws are incomplete and not consistent with each other. Incentives under these policies and laws are inadequate to sustain long-term and stable development of renewable energy.
- Lack of necessary renewable energy resource survey and assessment. Due to poor resource management system, man technical and economic feasible renewable energy technologies can't be promoted widely and some high-quality renewable energy resources are not exploited in rational way.
- Weak industry infrastructure for renewable energy technology development. Except hydropower, solar heater and biogas, other renewable energy industries are still infant industry. Most of the key technologies and equipments are relying on import, which lead to difficulty to cut down product cost.
- Lack of market mechanism for renewable energy promotion. Most of renewable energy technologies are in weak competition position, which limits the market expansion and sustainable development

5.1.2 Nuclear

Nuclear power generation will increase quickly in future, but still represents a small share, because of its high cost. The model results shows that nuclear power generation could only reach 256 TWh in 2020, compared with 16.7 TWh in 2002. The installed capacity will be 40 GW in 2020. The technical risk nuclear power is the ensure the raw material supply. And the financial risk of nuclear is the high cost and public against opinions.

5.1.3 Methane utilization

There are mainly two type of methane can be used for energy and one is the landfill gas and the other is coal bed methane.

In China, the municipal solid waste (MSW) and the (LFG) are taken as biomass resource from the view of energy utilization. However, considering the large contribution of LFG to GHGs, LFG is taken as a special sector of renewable energies in this report. At present, the annual MSW output is over 100 million tons, and over 80% are disposed by landfill. MSW in China is expected to reach 150 and 210 million tons per annum in 2010 and 2020 respectively. In 2010, if 70% is disposed by landfill, and considering annual 80 cubic meters of LFG is generated for one ton of MSW, the annual LFG amount will be 8.4 billion cubic meters. And in 2020, If 60 percent of MSW is disposed by landfill, about ten billion cubic meters of LFG could be produced.

China's in-mine CBM recovery started from 1950s. Up to now it has a history for more than 40 years. Up to the end of 2000, underground gas recovery systems and surface gas distribution systems had been built in China's 184 coal mines with annual methane recovery up to 858 million m^3, of which the annual drainage amount from Fushun and Yangquan mining areas exceeds 100 million m3, respectively. However, on the average the CBM recovery efficiency was not high, only 23%. China's in-mine gas recovery technologies have matured. The major task at present is to popularize the use of high efficiency CBM recovery technologies and put various recovery technologies into use to achieve comprehensive gas recovery as well as increasing recovery efficiency.

With regard to CBM surface development, started from 1970s, surface CBM pre-drainage tests were carried out in Fushun, Jiaozuo and other mining areas. China started introducing overseas CBM technologies at the beginning of 1990s. Currently, China's CBM is on the stage of full-scale exploration and development. Up to now, more than 200 surface wells have been drilled in China. The highest single well daily output reached 16,000 m3.

In recent years, big progress is made in domestic enterprise-run CBM projects and joint venture projects in China. Up to the end of 2000, 29 CBM wells had been drilled by China United CBM Corporation (CUCBM), and a group of wells which contains 10 wells had been built in south east part of Qingshui basin. Of the 10 wells, 3 wells have reached industrial gas flow with daily gas output 7000 m3, 10,000 m3 and 16,000 m^3, respectively. In 1999, China National Petroleum (Oil and Gas Group) Corporation (CNPC) had also completed 6 pilot-wells group test, of which one well daily output reached 7000 m^3. In the foreign cooperation field, up to the end of 2000, CUCBM had signed 11 product sharing contracts with 6 foreign companies Texaco, Arco, Phillips, Lowell, Greka and Virgin, respectively.

China's CBM utilization started in the end of 1970s. In 1982, CMM utilization projects were formally integrated by the government into the national investment plan on energy saving and capital construction. Up to now, China has got approximately 60 CMM utilization projects started and put them into operation. In 2000, nearly 500 million m3 of CBM was utilized.

At present, CBM recovery is mainly drained from underground recovery systems. There has been no industrial size methane recovery from surface wells. CBM recovered from underground recovery systems is usually medium heating value gas. Its methane concentration ranges from 30% to 50%. Such CMM is mainly used as household use fuel and industrial boiler fuel. A small amount of mine methane is used for power generation and chemical products making. The fuel gas supply in the city of Fushun and city of Yangquan is mainly come from CBM recovered from the local coal mining area. CBM power generation projects have been built in 3 China's mining areas. In Jincheng mining area a power plant (5.6 MW) which takes CMM as fuel, and a CBM power plant (0.24MW) which uses CBM recovered from surface wells, have been set up, respectively. There are 3 coal mining areas in China that use CBM to produce carbon black.

The technical risk for both LFG and CBM is the collection of the gas and financial risk of them is relative small due to them is the hot point of CDM project developers and the income of CERs can be used reduce the financial risk of LFG and CBM utilization in China.

5.1.4 Energy efficiency

There are a lot of national activities for energy efficiency, which are:

- Energy Efficiency was list into the national priority areas: it was considered as a crucial component of national energy and sustainable development strategy and will be carried out on a long-term base to incentive the development of energy conservation in the whole country.
- Facilitate the Industry structure adjustment: One major approach to build energy efficient Industries and society is to facilitate the structure adjustment of industries, productions and energy consumption.
- Technology innovations are encouraged, especially in the information industry, an important driving force for economic increasing with low energy consumption. The proportion of high-new tech industry in the national economic is expected to increase constantly.
- Price leverage: by strengthening the energy pricing reform, the price of various energy resources is to be formulated in order. It is expected to create a price incentive system in favor of energy conservation.
- Improving the legislation: including the amendment of Energy Conservation Law, the formulating of subsequent implementation regulations etc. Legislation is an

effective instrument to improve and supervise the energy conservation development overall, and the legislation system framework shall be based on the Energy Conservation Law, supporting by relevant regulations and standards.

- Facilitate the development, demonstration and promotion of energy conservation technologies: science R&D activities shall be taken for those general, crucial and up-to-date energy conservation technologies, as well as the demonstration of primary energy conservation projects, to contribute to the industrialization of the technologies.
- System creation and innovation based on the market mechanism, that was to promote 1) the setting of the information publication system; 2) the comprehensive energy plan and the demand side management; 3) the implantation of EE production certification and EE identification systems; 4) Energy Performance Contracting system; 5) the investment guarantee mechanism in order to improve the EE technology service system; 6) EE Volunteer Protocol.
- Enhance the energy conservation efforts in key enterprises: fulfill the Regulation on Energy Conservation Management of Major Energy Consumption Enterprises, and the Management Measures on Electricity Conservation, to strengthen the supervising to those enterprises with annual consumption over 10,000tce.
- Promotion, training and capacity building activities: carried out the promotion campaigns on a wide, intensive and long-term base to increase the public awareness. To adapt the energy conservation into the school course, both for conventional school and professional/technology education systems.

The major challenges and barriers for promoting energy efficiency are:

- Lack of awareness. Although the central government has put a great emphasis on the energy conservation in the National Energy Development Plan. The public and private sector still do not have a strong awareness on energy conservation in their energy consumption pattern.
- Lack of effective implementation of currently regulation. The Energy Conservation Law was established in 1998, but it has not been effectively implemented.
- Lack of incentive policies. It has been proved from international experience that energy conservation is the area where the market adjustment doesn't work very well, which need the government guiding and directing from macro policy.
- New market mechanism for energy conservation has not been applied popularly. Most new energy conservation mechanisms are still in the demonstration and pilot, such as DSM, EMC/ESCOs, energy efficiency labeling management, voluntary agreement, etc.
- Lack of capacity in energy conservation technology development and promotion. Energy conservation is depending on technical development. Due to the lack of

fund. R&D on advanced energy conservation technologies in China is insufficient compared with the huge market demand.

- Lack of energy conservation supervision and capacity building of energy services organizations. There are 145 energy conservation service (technical service) centers around China, most of which are assigned by government to implement inspection and monitoring. However, the capacity of these centers is quite weak on technical capacity, information dissemination, inspection facilities and funding and human resources.

5.1.5 Hydrogen technology

The current market for hydrogen is divided into two segments: captive users, who produce the hydrogen at the location where it is to be used, and merchant users, who have their hydrogen delivered to the point of use. In the United States and worldwide, the captive market is the larger, and includes chemical producers (such as ammonia, methanol, hydrogen peroxide, and pharmaceuticals), refineries, fat and oil hydrogenation, and metal production. The smaller merchant market serves industries such as electronics manufacturers, float gas producers, and public utilities for generator cooling in nuclear plants. Currently, most the hydrogen comes from the conventional energy, such as coal and oil, it will be not a carbon free technology. Only renewable energy or nuclear power based hydrogen can be recognized as the carbon free technology. A recent study examined the potential for hydrogen production from renewable resources, including solar and wind. The potential for hydrogen production from wind and solar is very large. The study shows that the China has ample solar and wind resources to meet its transportation fuel needs, and shows where those resources are most prevalent. However, renewable energy systems face challenges to reduce the cost of electricity and to independently meet the energy requirements of distributed fueling stations.

5.2 The potential role of international cooperation in reducing these constraints

5.2.1 Multilateral cooperation

5.2.1.1 International organizations

There are several international institution which worked in China related to energy, environmental and climate change issue, they are:

- UNDP: The priorities of UNDP in China are poverty, gender, equity, development and environment. Environmental issues are local environmental issues, not global issues. The energy unit of UNDP in China is thus having a focus on development rather than global climate change. While as an execution agent for GEF, which channel some climate change related fund to China, UNDP has some work focus on climate change. All UNDP projects in

China have to be approved and accepted by Chinese government, and the major model of UNDP is to collaborate with the government agencies. Regarding energy and environmental related issues, it's main partners in China are NDRC, MOST and SEPA.

- World Bank and ADB: Priority: WB and ADB are financial institutions in China focusing on sustainable development, with greatly influence on the market of the renewable energy and energy efficiency. Current priority of their work is on improving investment environment, rural development and sustainable development. These two organizations do have some policy work, but which is motivated by the concern of their investment profit in renewable energy and energy efficiency projects. Their partners are mainly the government agencies. Funding from Other international/ bilateral organizations could be included in their financing portfolio. Process: By long-term low interest loan, the projects are invested in line with their strategy and directions. WB and ADB are also quite rigid in terms of adapting to changes.

Most of the climate change related work of UNDP, ADB and the World Bank is through a support of GEF. Currently, there are several projects, which financed by GEF for renewable energy, energy efficiency and methane collection and utilizations, which are:

1) World Bank Energy Conservation Service and Capacity Building Project

The objective of this project is: to introduce, demonstrate and promote the new energy saving project concept of Energy Performance Contracting in China utilizing the funds and technology supports from UN, WB and GEF; to frame a new energy conservation incentive mechanism with marketing orientation; to move the existing market barriers; to realize the projects mature in technologies and feasible in economic on a general base; to expedite the energy conservation industrialization, improving the energy efficiency and relieving the GHG emission. The establishment of demonstration EMC is the main outputs of this project. Three EMCs have been identified and set up in Beijing, Liaoning and Shandong, plus one non-profit Energy Efficiency Information Dissemination Center of NDRC. To address the financing barriers of Energy Conservation Service Companies in China, the WB/GEF CECP Phase II set up the Loan Guarantee Special Fund (currently 22 million dollars) and had China Economic Technology Investment Guarantee Co., Ltd to be the partner to offer the energy conservation service companies in demands with face to face assists in approaching loan or equity financing via the guarantee program.

2) UNDP Energy Conservation Partnership

The objective of this project is to assist China in improving the energy conservation and energy efficiency in the major energy consumption sectors, supporting China to

create a market based sustainable mechanism for energy efficiency, forming a comprehensive effective energy saving policy and regulation system and enhancing the relevant capacity building provided the market economic. The launching and implementation of this project is in favor of the formulating, performance and improving of legislations, policies, and standards relevant to energy conservation. It turns to be a driving force to carry out the national target of an Economical Society.

This project consists three components: 1) demonstration of energy conservation volunteer agreement in the industry sector, formulating and amendment of energy conservation design standards, development and dissemination of EE standards and labeling in primary Industry and households, development of energy management information systems in the primary energy consumption enterprises and establishment of the energy report system; 2) in the energy efficiency building area, set up a data collection system of building energy consumption, invent the building EE standards and policies and the implementation, information dissemination on the building energy conservation, and facilitate the overall improvement in the building energy conservation technologies and products; 3) in the comprehensive energy conservation area, enhance the capacity building of the energy conservation center, empower the implementation of Energy Conservation Law, the policy study and implementation of energy conservation financing, and the public awareness arising on the energy conservation, etc.

3) China Renewable Energy Scale-Up Project（CRESP）

It is a cooperative project among China Government, the World Band (WB) and the Global Environment Foundation (GEF) for renewable energy policy development and investment. The objective of this project is to research and formulate the renewable energy development policies in China by carrying out a energy resource survey and referring to the good practice in the developed countries. A scale-up development of China renewable energy power generation is expected, starting with pilot projects, that supply the market with efficient and commercialized electricity. The purpose of this project is to: impact the scale-up development of the renewable energy, substitute the firepower with RE power, and relieve the environment pollution. It will benefit the adjustment of energy structure, the development of the western China and the sustainable development.

4) China Renewable Energy Development Project

The NDRC/WB/GEF REDP project is an international assisting project carried out jointly by NDRC and WB in the RE area with financing support from GEF. This project aims to assist granted countries to create a sustainable market for both wind and solar energy technologies: 1) increasing the electricity supply without destroy to the environment; 2) providing electricity to the household and business of the remote area within the territory of the granted country; 3) supporting to improve the equipment

quality and performance, strengthening the service capacity, and contributing to the RE industrialization.

5) Capacity Building on Rapid Commercialization of Renewable Energy in China

The goal of this project is to accelerate the development of some key RE technologies by commercialization utilization in special markets. The commercialization capacity building activities were carried out for 5 selected technologies: 1) technology support to the commercialization of grid-connected wind farm and carry out the upfront preparation of the large-scale wind farm development; 2) demonstration project of large and medium scale biogas waster water treatment, carry out relevant policy study, develop the national action plan for biogas and accelerate the commercialization of biogas projects; 3) demonstration projects for rural wind/solar/wood hybrid system and explore the commercial way to address the electrification of villages; 4)set up a national level certification and examination center for SWH, develop the standards and promote the standardization of SWH market, and realize the healthy industry development; 5) demonstrate the bagasse co-generation projects, promote the utilization of efficient boilers, and explore ways of optimized utilization of biomass, as well as energy efficiency improvement and pollution decreasing.

The major problem of GEF is improve the project approval and implementation efficiency.

5.2.1.2 UNFCCC (Kyoto Protocol)

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) came into force on February 16, 2005, and is now fully operational. Most of the industrialized countries have committed to reducing their aggregate emissions of greenhouse gases (GHGs) by 5.2 percent below 1990 levels during the protocol's first commitment period (2008–2012); the United States and Australia have so far declined to ratify it. To make the process cost-effective, the following three flexible mechanisms were established under the protocol:

- Joint implementation (JI) among Annex I countries
- The Clean Development Mechanism (CDM) for use between non-Annex I (developing) and Annex I (developed) countries
- Carbon trading among Annex I countries

The CDM provides opportunities for emission reductions as well as sustainable development in developing countries. China's economic growth is based mainly on fossil fuel energy—especially coal, which represents about 70 percent of its total energy consumption. China is therefore recognized as one of the most important countries where there is potential for reducing GHG emissions as well as for CDM participation. The Executive Board (EB) of UNFCCC and Methodology Panel (MP) supplied technical support for CDM projects development in China.

Renewable energy, energy efficiency, and methane are the top CDM priorities in China. There are a variety of possible CDM projects, mainly in the areas of energy-efficiency improvement, renewable energy development, coal-bed methane, power generation, and forestry. The total GHG reduction potential in China is estimated to be about 777 million metric tons (tonnes) of carbon-equivalent, which includes 545 million tonnes from energy efficiency, 138 million tonnes from renewable energy sources, 67 million tonnes from coal-related methane, and 27 million tonnes from fuel switching and new technologies for power generation. Potential CDM projects cover many sectors including industrial energy efficiency, power, transportation, renewable energy, agriculture and livestock, municipal or solid wastes, and changes in land use. However, current government priorities in China are energy efficiency, renewable energy, and methane. The ongoing and planned future efforts on mitigating GHG emissions clearly point towards a substantial potential for achieving emission reductions in China through the CDM.

On June 30, 2004, the Interim Measures for Operation and Management of Clean Development Mechanism Projects in China, which is the basis of China's CDM project management, came into effect. According to the measures, more than a dozen Chinese governmental organizations are involved in CDM-related affairs. Some of those directly involved in the management of CDM projects include the National Coordination Committee on Climate Change, the National CDM Board (which works under the committee), the National Development and Reform Commission (NDRC) (China's designated national CDM authority), and a CDM project management institute established under the National CDM Board.

The NDRC and the Ministry of Science and Technology (MOST) serve as co-chairs of the board, while the Ministry of Foreign Affairs (MFA) serves as vice chair. Other board members are the State Environmental Protection Administration, the China Meteorological Administration, the Ministry of Finance, and the Ministry of Agriculture. The board has already accorded host country approval to ten CDM projects under various sectors submitted by project developers in China. All of these projects are in the renewable energy and landfill sectors. More then 50 other projects have already developed their project design documents (PDDs) or prepared their project idea notes (PINs). There are a number of facilitating institutions that can assist project developers in the preparation of their PIN and PDD, as well as a number of international institutions that have opened offices in China to facilitate the validation, verification, monitoring, and certification of CDM projects. By October 12, 2006, about 40 projects have already been successful in obtaining their registrations, and another 300 projects have been got the Letter of Approval.

5.2.1.3 AP6 Partnership

The Asia-Pacific Partnership on Clean Development and Climate (AP6) is a ground-breaking climate change approach bringing together key developed and developing countries on practical, pro-growth, technology-driven efforts. The Partnership was established by Ministers from Australia, China, India, Japan, Republic of Korea and the United States at the Inaugural Ministerial Meeting in Sydney, January 2006. Ministers agreed to a Charter, Communiqué, Work Plan and the establishment of eight public-private Task Forces to implement the AP6 agenda.
On 1 November 2006, the Prime Minister released Action Plans developed by Task Forces, and announced the 41 projects of the 90 mentioned in the Action Plans, that had received in-principle Australian Government funding of approximately AUD59 million. This contribution represents part of the AUD100 million that has been committed over five years to the AP6. The remaining funds will be available for new projects brought forward as the AP6 progresses. Projects may also change as they are further developed and implemented, therefore some Australian funding is contingent on project milestones being met. The Prime Minister released a booklet (pdf, 2.4 MB) setting out the work of the Task Forces to date and details of projects that have received Australian support. The Task Forces cover the aluminum, building and appliances, cement, cleaner fossil energy, coal mining, power generation and transmission, renewable energy and distributed generation and steel sectors. Task Forces have developed Action Plans that feature over 90 project proposals, reflecting the AP6's vision of delivering greenhouse emission management, national pollution reduction and energy security benefits through efforts that also support economic development. The projects receiving funding from the Australian Government are drawn from all Task Forces with a focus on cleaner fossil energy and renewable energy and distributed generation. These projects will involve financial and in-kind support from other AP6 Partners and industry participants, to provide the maximum outcome for Partners from their investments.

In general, AP6 is supplementary program with CDM and it can be a platform for technology and financial cooperation in the filed of carbon reduction. Chinese government has put a lot effort for the cooperation and all the working group have been set up. The major issue is that, if the partners can put the extra money for the clean development mechanism and solid projects for cooperation are launched.

5.2.1.4 REEEP

The Renewable Energy and Energy Efficiency Partnership (REEEP) is an active, global public-private partnership that structures policy and regulatory initiatives for clean energy, and facilitates financing for energy projects. Backed by more than 200 national governments, businesses, development banks and NGOs, REEEP is uniquely placed to contribute to international, national and regional policy dialogues. Our aim is to accelerate the integration of renewables into the energy mix and to advocate energy efficiency as a path to improved energy security and reduced carbon emissions, ensuring socio-economic benefits. With a network of 8 regional

secretariats and more than 3,500 members, REEEP has the ability to affect change worldwide. The partnership has funded more than 50 high quality projects in 44 countries that address market barriers to clean energy in the developing world and economies in transition. These projects are beginning to deliver new business models, policy recommendations, risk mitigation instruments, handbooks and databases. The partnership's goals are to:

- Reduce greenhouse gas emissions
- Deliver social improvements to developing countries and countries in transition, by improving the access to reliable clean energy services, and by making REES more affordable
- Bring economic benefits to nations that use energy in a more efficient way and increase the share of indigenous renewable resources within their energy mix.

REEEP was conceived at the Johannesburg World Summit on Sustainable Development in August 2002 and was developed via an intensive consultation process in 2003 covering a wide range of stakeholders at the national and regional levels. In June 2004, the REEEP was formally established as a legal entity in Austria with the status of an International NGO. The partnership is funded by a number of governments including: Australia, Austria, Canada, Germany, Ireland, Italy, Spain, The Netherlands, New Zealand, The United Kingdom, The United States and the European Commission.

Currently, China received more than 10 difference projects support with about 700,000 Euros. In general it is not a big money, however, the REEEP activities have made a significant awareness for renewable energy and energy efficiency through the support of enabling financing, policy orientation, road map development and best practice dissemination.

5.2.1.5 CSLF (international Carbon Sequestration Leadership)

The international Carbon Sequestration Leadership Forum (CSLF) is a voluntary climate initiative of developed and developing nations that account for about 75 percent of all manmade carbon dioxide emissions. Members engage in cooperative technology development aimed at enabling the early reduction and steady elimination of the carbon dioxide which constitutes more than 60 percent of such emissions - the product of electric generation and other heavy industrial activity. In 2005, the Forum and the technologies it seeks to develop were identified by international bodies as pivotal in dealing with greenhouse gases and their ultimate stabilization. In July 2005, the G-8 Summit endorsed CSLF in its Gleneagles Plan of Action on Climate Change, Clean Energy and Sustainable Development, and identified it as a medium of cooperation and collaboration with key developing countries in dealing with greenhouse gases.

Many CSLF-approved demonstrations are meant to identify and further quantify the potential of storage sites. At present there are 17 demonstrations - 10 endorsed by chief energy executives of CSLF member nations in their 2004 Ministerial Meeting, and seven recently accepted by the Forum's Policy Group for Ministerial action in 2006. The endorsed demonstrations include the CASTOR Project, whose ultimate objective includes storage of up to 30 percent of Europe's industrial emissions; and the CO_2 Sink demonstration near Berlin, whose objectives include assessing the potential of a reservoir-type that underlies much of Europe. New activities include the first projects in developing nations - two in China and one in India. One project in China will begin to quantify a range of storage capacity in a variety of geologic formations and the other will examine the potential for storage in unmineable coal seams. The activity in India will focus on the storage potential of basalt formations, which underlie much of the sub-continent. An early assessment of basalt in the United States suggested the potential to take all emissions for hundreds of years.

The CSLF was organized as a technical working group to develop technology and processes for dealing with greenhouse gases independent of other climate-change activity. It acknowledges the International Energy Agency's finding that the world will have to rely on fossil energy for economic growth and stability during the indefinite period required to pass from the present to a point in the future where low- and no-carbon energy sources can meet most requirements. The challenge is to reduce emissions while fossil-energy use rises. The Forum involves the world's major users and producers of fossil energy in collaborative, constructive activity on the main greenhouse gas. Members represent the world's largest blocs of economic activity, including the North America Free Trade Area, the European Union and the leading economies of Asia.

Members are: Australia, Brazil, Canada, China, Colombia, Denmark, the European Commission, France, Germany, Greece, India, Italy, Japan, Mexico, the Netherlands, Norway, Russia, Saudi Arabia, South Africa, South Korea, the United Kingdom, the United States. In addition, all Forum members are eligible to participate in the U.S. FutureGen Project, which will be the prototype for zero-emissions electric generation with coal. Based on coal gasification, the project will integrate now-in-development technologies to capture and store carbon dioxide while producing hydrogen and low-carbon fuels for other uses such as transportation. Electric generation is the world's largest source of manmade carbon dioxide emissions; transportation the fastest growing. Letters of invitation were sent in August 2005 from U.S. Secretary of Energy Samuel Bodman to the appropriate ministers of member countries.

5.2.2 NGOs

There several NGOs are working in China actively for climate change activates, which WWF, Green Peace and a lot of foundations as well as GWEC (Global Wind Energy Council) and others. The major activities of the NGO for climate change are information dissemination and public awareness, which include:

- Wind-12 in China and wind price study;
- Golden Standards for CDM;
- 20 ways for 20% emission reduction;
- Entrepreneurs training for sustainable energy business and others.

5.2.3 Bilateral activities

Beside the multiple-lateral international cooperation, there are a lot bilateral cooperations for the carbon reduction, which mainly are:

1) EU-China Energy and Environment Partnership: every year, EU will support several energy efficiency, renewable energy and other carbon reduction based technical assistant projects in China and the FP7 is open for China and the overall goal of the cooperation is to improve the energy efficiency, enlarge the utilization of renewable energy, cultivate and develop the nature gas market, and encourage the sustainable energy utilization.

2) Fossil Energy Protocol between the United States and China: The Fossil Energy Protocol between the United States and China was recently extended to 2010 at a signing in Beijing, China, in April 2005 between the U.S. Department of Energy and China's Ministry of Science and Technology. The Protocol has five Annexes under which joint projects are conducted based following annexes : Power Systems, Clean Fuels, Oil and Gas, Energy and Environmental Control Technologies and Climate Science. There are a number of current projects under the various Annexes. These include: 1) Distributed Generation Fuel Cell Seminar in 2005 (proposed), Study of Long-term Ecological, Environmental and Economic Impacts of Development and Operation of a Coal Liquefaction Plant in China, 3) Seminar Explaining Use of Publically Available DOE Oil & Gas Software; Technical Feasibility Study of Coal Mine/Coal Bed Methane Project (proposed), 4) Study of CO_2 Sequestration with Ammonium Carbonate; Mercury Emissions Project; SO_2 Reduction Briefing; Joint U.S.-China Carbon Capture and Sequestration Center (proposed).

3) Climate Change Partnership of Australia and China: In September 2003 the Government of Australia and the Government of the People's Republic of China agreed a Joint Declaration on Bilateral Cooperation on Climate Change. This was enhanced by the signing of a Memorandum of Understanding on Climate Change Activities (MOU) on 16 August 2004. The MOU provides for cooperation between Australia and China on climate change with the aim of: enhancing scientific understanding of climate change; achieving or facilitating greenhouse gas emission reductions; building capacity to address and adapt to the possible impacts of climate change; facilitating mutually beneficial opportunities in relevant technologies, products and expertise; and exploring the possibilities for building support for an equitable, practical and effective global response to climate change. To meet these goals the MOU provides for cooperative activities and projects under a number of themes including: 1) climate change policies and measures; 2) technology cooperation; 3) renewable energy and energy efficiency; 4) climate change science; 5) climate

change impacts and adaptation; 6) greenhouse gas inventories and projections; 7) capacity building and public awareness; and 8) any other areas that may be mutually decided by the parties.

4) Others: Beside the bilateral cooperation, Canada, Japan and a lot of EU countries have signed the cooperation for climate changes with China.

6 Successes and failures to reduce the carbon intensity of growth and overall emissions

There are many successful and failure stories of emission reduction in China, here and after are some of stories of the successes and failures in the emission reduction in China.

6.1 Success story

1) Small hydro power program in China: Sine early of 1980's Chinese government launched a special program for rural electrification by small hydro-power applications. The target of the program in supply electricity to rural area to meet the power needs in rural. The government set up a special policies framework, which are: 1) self built, 2) self management and 3) self use. The central and local governments only supplied technical support and less than 10% of financial subsides. By the end of 2006, more than 40GW of small hydro-power has been set up with annual power generation of 120 TWhs and the annual emission reduction of GHG is about 120 million tons of CERs. Experiences of the successful story of the program are:

   - Set up right policies framework for reach the target;
   - Develop a special mechanism to set up a relationship of with all of the stakeholders;
   - Subsides is only the complementary measure for the program implementation;
   - Emission target is the by production of electricity supply for rural;
   - Rural or the final user participation is essential for the successful of the program

2) Renewable energy law: in the early of 2005, renewable energy law was lunched in China and the law became effectiveness in January 1, 2006. by of one year of implementation of the law, following successful has been made: 1) Market quickly expansion: by the end of 2006, wind power increased about 1334 MW, as the contrast, the accumulated installation of wind power was only about 1260 MW by the end of 2005; Solar PV production capability increased 300% from 150 MW to 600 MW. 2) multiple investments involvement, during 2006, about 8 renewable energy companies were listed in London and New York stock market, the total value of the company is over 20 billion US$. 3) manufactures are growth up, by

the end of 2006, more than 30 wind turbine manufactures were set up include largest international players, such as GE. The reason of the successful of the law are:

- Selected the successful system for implementation, such as feed-in tariff system for renewable power;
- Put the market as main body for the law implementation;
- Set up clear target for development, for example, 30 GW of wing by 2020;
- Set up detailed implementation regulation. Based on the law, 12 of detailed regulations should be issued, by the end of 2006, about 10 of them have been issued.

6.2 Failure story

There are also many failures for emission reduction control, for example of energy efficiency law In order to promote energy efficiency, in the early of 1990s, Chinese government started to issued the energy conservation law. By about 8 year argument, the law had been approval by National People's Congress in 1998. However, after almost 9 years, the law did not make great contribution of promoting energy efficiency. Especially during the 2003 to 2006, the energy use in China was increased about 1 billion tons of TCE. Then, by the end of 2006, the Chinese government tried to modify the Law, since the very low efficiency of the law implementation. The major reasons of the failures of the law are:

- Without the market based mechanism of for promoting energy efficiency;
- Shortage for system support and mainly focused on technologies system; For example, by 8 years of the implementation of the law, there were no one detailed regulation to be issued.
- Do not have economic incentives for the support energy efficiency activities;
- Without cleaned target the system requirement and only said that energy efficiency is a priority, but how no one understand.

7 Discussion of Kyoto and after Kyoto

7.1 Successes and failures of Kyoto

The major successful story of Kyoto was the implementation of CDM. By the end of March, 2007, there were 367 protracts have been approval by Chinese government and more than 40 projects have been got registration in EB. The reason of successful of CDM is the market based implementation system and business driving. The failure of CDM is also the deeper involvement of business orientation. For example, renewable energy, energy efficiency and methane are the three priorities. However, the World Bank and other stakeholders, in order to quickly meet the buyers demand, lunched the HFs program, which are with very fewer number of the project, within very

short period, to buy millions tons of CERs. As the results, the CERs market demand is quickly to be sufficient and which made the renewable energy\energy efficiency and methane CDM projects be in the difficult situation. Take China as example, HFs and other chemical CERs takes absolutely the majority of the delivered CERs. As the contrast, energy efficiency takes very small share.

In other word, the priorities of the business people, include World Bank, some time it is business people, for example in the CERs case, is not consistence with national development strategy in most of the situation. Therefore, the EB should ask international financial institutions, such as World Bank have to do the most difficulty thing, and always take national priority as their priorities.

The most important failure thing of Kyoto is the failure of technologies transfer, even there are some programs, included REEEP, APP, GWEP, GBEP and other, the technologies transfer is not promoted. Even in the CDM, most of the case is money transfer, instead of technology transfer.

7.2 What should we do after Kyoto

Even there are many debates about after Kyoto. However, emission reduction will be first priority for all the parties. The only argument is how to reduce and control the emission. As a developing country, China will face serious challenge, fast economy growth and fast energy demand growth. Therefore, energy efficiency, renewable energy will be the most important priorities in China's energy and emission control strategy. By the middle of April, Chinese government will publish its measures of climate changes, and energy efficiency and clean energy have been put in to the first priorities. Meanwhile, Chinese government put effort to develop its national energy development strategy by 2030 and beyond, energy law has put in the national agenda of legislation. All the measure indicated that, Chinese government is going to take real step to face emission and other climate change issues.

However, the successful of Chinese government policies relied on the international support. For example, clean energy technologies development, Nuclear Power development needs most advantage technologies for the large scale application. However, the technologies are controlled by USA, Japan, France and other developed countries. Wind turbines and solar PV the key technologies are controlled by USA, Germany and Japan. Most the high efficiency technologies are located in France, Japan and other developed countries. In other words, the successful of emission control will depended on the successful of technologies transfer, which include hardware and software technologies transfer.

8 The improvement needs for international cooperation

There are many international cooperation activities for climate changes or carbon reduction in China, however, the major improvement needs of the cooperation are following:

- Improve the situation of shortage of sufficient financial support: Based on the financial needs analysis for carbon reduction through the energy efficiency, renewable energy and carbon sequestration, about 10 billion US$ should be invested for clean investment activities every year, however, total financial support from international support is less than 1 billion US$, it is only the 10% if basic needs for the clean development. Especially the financial support for private sectors is much less than theirs requirement. Currently, the all the multilateral cooperation program, such as AP6, REEEP and CSLF, are short financing support for their activity implementation. Therefore, extra financial support should be mobilized for the carbon emission reduction in China and other developing countries.
- Improve the efficiency of project implantation mechanism: The Existing financial support system is good, bud with complicated approval procedures, which leaded the project implementation with very low efficiency. For example, same CDM project needs to develop same bureaucratic dominations and go through same complicated approval procedures. Another example is the implantation efficiency of GEF is much behead of the needs of renewable energy and energy efficiency development in China. Therefore, bureaucratic approval process and documentation system should be improved.
- Set up a mechanism for promoting technologies transfer: technology transfer is recognized as the one of the major instruments for the carbon emission reduction. However, there are very few successful stories for technologies transfer. Currently, a lot of carbon free or low carbon emission technologies is hardly delivery to China or with very expensive cost, such as wind manufactures, solar PV raw materials and others. Some time the intelligent property protection is the barriers of the high efficiency low carbon technologies dissemination. Therefore, approach for technologies transfer should be set up as soon as possible.