The Development and Climate

Country Study: China

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1. Introduction

It is well recognized that the world should response to climate change which is fully emphasized in ratified United Nation Framework on Climate Change Convention(UNFCC). After UNFCC went into force in 1994, much discussion and international negotiation followed to promote international and domestic action. Kyoto Protocol is regarded as a significant progress in moving to actual action for climate change. Quantified target for developed countries was given in the protocol, and international collaboration mechanisms were defined to provide incentive for lowing cost in developed countries and involvement of developing countries. However so far Kyoto Protocol does not ratified by few key countries including United State and Russia, which gave difficulty for Kyoto Protocol to get in force. Hugh argument and intensive discussion has taken about the implementation of Kyoto Protocol. The fact is we made small progress in six years after Kyoto Protocol raised in 1997. We need to look for more efficient way to the world to work on climate change.

One of the criticisms from countries not ratify Kyoto Protocol is major developing countries including China do not take commitment in Kyoto Protocol. By following the criteria defined in UNFCCC, it is reasonable that development countries should move ahead. Therefore the argument will not have final conclusion. By following this forum, each country can go there own way. But the world really need to move for climate change.

However in the meantime, developing countries such as China made huge progress on energy efficiency improvement, renewable energy development, reforestation etc. All of these efforts contribute a lot for climate change. Sustainable development Strategy was set up as basis national development strategy in China. A package of national development plan and policies were designed based on the sustainable development strategy. Many of the plans and policies are consistent with climate change policies. Increase economy income is the priority in China while domestic environment issues is the first concerning for environment policies. Recently published IPCC Third Assessment Report and many other studies identified opportunities for co-benefit or ancillary benefit for domestic environment policies and climate change policies.

Work together with various research teams in developed countries and developing countries, an alternative approach to the challenges that face the global community brought on by the climate change problem was developed. In this approach, development is placed before climate change, reversing existing frameworks. This so-called *Development First* approach emerged from the recognition that many efforts undertaken within developing countries as part of sound development initiatives, are also beneficial from a climate perspective. This opens up the possibility of incorporating climate change (and other environmental) policies in development strategies and programmes that are vitally important to developing countries decision-makers. Furthermore, it is clear that strong international co-operation will be needed to realize the emissions reduction needed in the long run. The world is far from achieving such co-operation at this stage and new perspectives have to be explored to find common ground upon which international policies can be built.

Therefore it is relative easy way to move ahead for climate change by supporting domestic development policies or domestic environment policies in developing countries. This study will look for benefit by focusing on domestic development target, development strategy, energy policies, environment policies and food security. This report presents the case study for China.

2. National Scoping

2.1 Social Economy Development in China

After reforming and opening from beginnings of 1980s, China experienced rapid economic development. From 1980 to 2001, annual average GDP growth rate is 9.8%, and GDP is 9593billion yuan in 2001, around US$1161Billion. GDP per capita reached 7543yuan per capita which is around US913 per capita, .

Between 1950 and 2000, China's economy not only grew rapidly, its structure also changed considerable. In 1952, China was still mainly an agricultural based economy with about half of the national income generated in the primary sector. During 1952~1978, China's economic growth heavily relied on industrial development, especially growth of heavy industries. While the average annual GDP growth rate was 6.1% during this period, the growth rate of the industry was as high as 11.4%. As a result by 1978, the industrial sector was by far the most important component of the national economy. In the following period (since the reform of policy and opening), China has been paying much attention to the development of agriculture, light industry and tertiary industry. In particular the service sector, in this period, grew faster than the economy as a whole – increasing the share of the service sector in the total value-added to 33% by 1998.

China's population is the largest in the world and it has grown strongly over the last century. In response to the prospect of rapidly increasing demands for all kinds of resources, the government of China has established several policies to control population growth. As a result, fertility rates have dropped strongly and also population growth rates has been steadily decreasing, to a level of less than 0.7% in 2000 (see table 1). It is possible this trend will slow down because it is allowed that for couples who are single kid in their family can have two children.

Table 1: Chinese population between 1970-1998

	1970	1975	1980	1985	1990	1995	2000
Population by the end of the year (10000)	82162	91769	98799	105851	114333	121121	126743
Of which: urban (%)				23.7	26.4	29.0	36.2
Rural (%)				76.3	73.6	71.0	63.8
Birth rate (%)				2.10	2.11	1.71	1.34
Death rate (%)				0.68	0.67	0.66	0.64
Natural growth rate (%)	2.50	1.72	1.35	1.43	1.44	1.06	0.69

Source: 2002 China Statistical Yearbook; before 1985 based on UN population data

The majority of the population lives in rural areas. However, along with the industrialisation, urbanisation also takes place: the urban population accounted for 26.4% in 1990, and it increased to 36.2% in 2000. This increase could have been larger, but policies are applied that try to limit large migration flows from the rural to the urban areas to allow for a balanced development of the capacity within cities.

China remains a developing nation with per capita GDP averaging only one-eighth that of developed countries.[i] China in 1980 ranked among the world's poorest countries and was strictly a planned economy. Economic liberalization was consciously adopted in 1979, with the Chinese government explicitly setting out to reduce energy demand growth while expanding its economy. The policies they set in motion reduced China's energy intensity as price reforms, privatization, and structural change within the economy. The resulting energy-intensity reduction remains unmatched in the history of economic development. Table 2 gives key social and economic development indicators.

Table 2 Key Social and Economic Development Indicators, 2000

Population growth rate	0.7 percent per year
Per capita GDP	Exchange rate= US$853; PPP=$3,475
GDP growth rate	7.8 percent per year
Residential electricity consumption	132 kWh per person per year
Persons below poverty line[1]	30.0 million

Persons without electricity	23 million
Persons per vehicle	79

Notes:
1. This level is defined as persons earning less than $0.20 per day, in exchange rate values.

2.2 Environment and Climate Change Issues in China

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 SO2. More then eleven provinces suffered acid rain damages. Figure 1 gives SO2 emission in China.

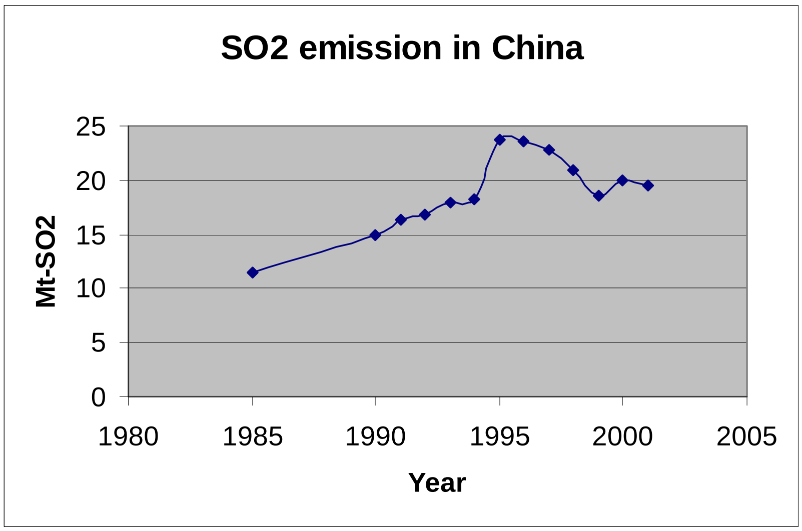

Figure SO2 emission in China

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[IPCC, 1997] and some revised emission factors in China, CO2 emission was calculated and is shown in figure 2[Davids et al, 2001].

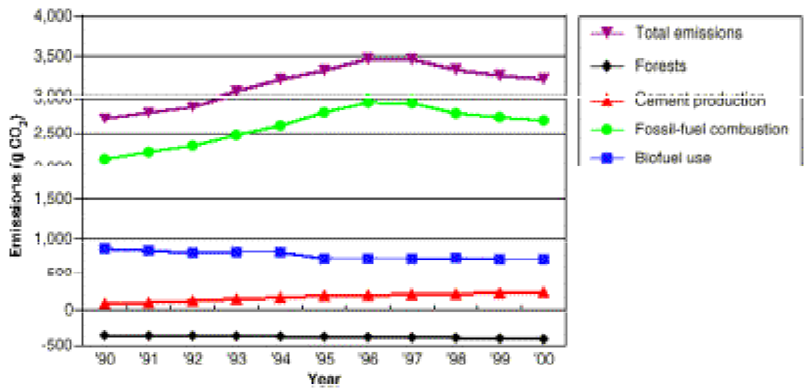

Figure 2 CO2 emission in China

What we see is there is a reduction on GHGs in China for last several years. However there is no any climate change focused policies were used. Local policies for energy development and environment could contribute fully to the response to climate change. So far priority faced by China and other developing countries is development. Local environment problem already prompt the understanding of sustainable development. Because of the limitation of human and financial resources, climate change issue is still not in the front of the list. International negotiation process made climate change topic more and more political. In some sense this put more difficulty to make action on climate change. Therefore the way to combine climate change with local development policies should be explored.

2.3 Energy in China

Because of rapid economy growth, total primary energy consumption increased from 400Mtce in 1978 to 1036Mtce in 2002, with an annual average rate 4%(see figure 3). Coal is the major energy in all energy use, taking share of 70.7 in 1978 and 66.1% in 2002 in total primary energy use(see figure 4).

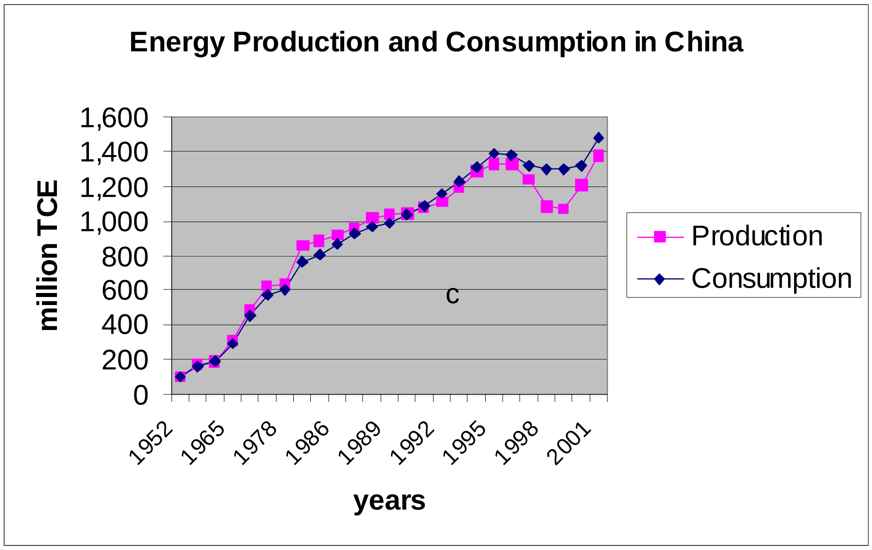

Figure 3 Energy production and consumption in China

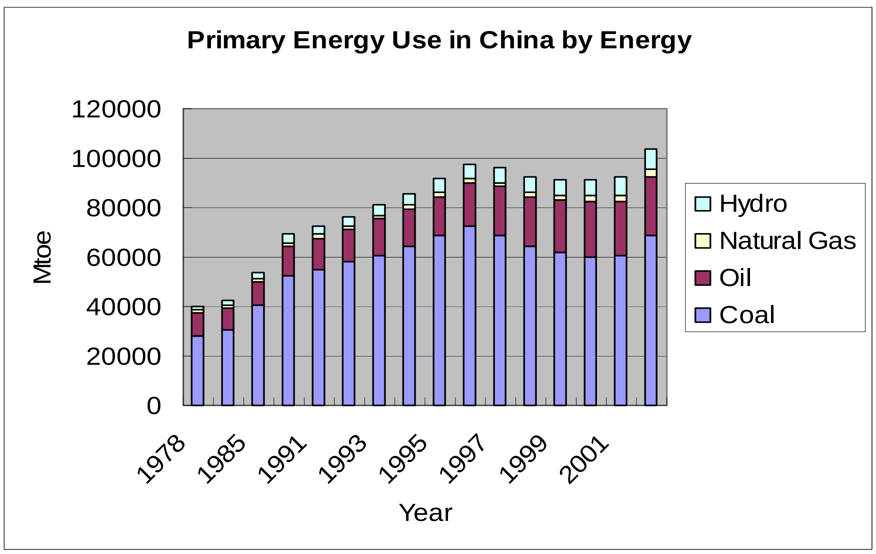

Figure 4 Primary energy use in China by energy

Although it is still hard to explain clearly the reason for the decrease of energy production and consumption, it could be mainly due to:

- Relatively bad situation in state owned enterprise. Large and energy intensive industry is mainly composed of state owned enterprise. For last several years, many state owned enterprise could not operate fully because of the impact of Asia Crisis and lost competition with private company. Overall state owned enterprise lost their benefit in 1997,1998 and 1999[China Statistic Yearbook 2000].

- Technology progress. Technology progress for energy saving is a long-term strategy from government and industry. Unit energy use for energy intensive product production is keeping going down. Significant progress had been made in steel making industry, power generation industry and building material industry.
- More clean energy use especially in commercial and residential sector. There was reduction in coal use and increase of gas use in these sectors after 1996.
- Effect of local environment policies. Because of the serious problem on local air pollution, some cities and province published strict regulation to limit use of coal. For example Beijing stop to use coal with thirdin ring road after 1998 and within fourth ring road after 2000. Low efficiency, small size village and township enterprise with heavy pollution were shut down by regulation from State Environment Protection Agency after 1997.
- Uncertainty on the statistic.

China is the largest coal producing and consuming country of the world. Between 1980 and 1996, total raw coal output increased from 620 Mt to 1397 Mt, the average annual growth rate is 5.2%. China's coal consumption accounts for 29.5% of the world total in 1996. Appendix A gives sectoral coal consumption for the period 1953-1995. 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 1996, total installed capacity increased from 66 GW (of which hydropower is 20 GW, accounting for 31%) to 236 GW (of which hydropower is 56 GW, accounting for 24%). In the same period, electricity output increased from 300 TWh (of which hydropower is 58 TWh, accounting for 19%) to 1079 TWh (of which hydropower is 187 TWh, accounting for 18%), as shown in table 2.5. During this period, both the average growth rate of installed capacity and electricity consumption reached as high as 8.3% per year. Electricity consumption structure is shown in table 2.6. The major consumers are industry, residential living, agriculture, commerce, transportation and communication, and construction, in 1996, their shares were 74%, 11%, 4%, 2%, 2% and 1% respectively.

The electricity industry made a considerable achievement in energy conservation. During the 1985-1996 period, specific coal consumption for electricity supply and for electricity generation decreased from 431 gce/KWh and 398 gce/KWh to 410 gce/KWh and 371 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 1996, nuclear electricity output is 14.2 TWh. There are 8 units with total capacity of 6600 MW which are ongoing constructing.

Between 1980 and 1996, total crude oil output increased from 106 Mt to 157 Mt (average annual growth rate is 2.5%). Of the total oil output in 1996, 142 Mt is produced in land, and the rest 15 Mt is produced in offshore. Appendix A shows the major oil product output. In 1996, crude oil output in China accounts for 4.7% of the world total.

In 1996, total natural gas output in China is 20.1 billion m^3, of which, 17.5 billion m^3 is from land, and 2.6 billion m^3 is from offshore. Total natural gas consumption is 17.11 billion m^3, of which 7.65 billion m^3 (45%) is used for producing chemical fertilizer and other chemical products, 6.72 billion m^3 (40%), is used as industrial fuel and 2.7 billion m^3 (15%) is used for urban residential uses.

The nation's per capita energy use amounts to only one-fifth European levels, though rapid economic growth continues to drive energy demand growth. In many rural areas, the Chinese people still lack access to commercial energy supplies—the oil, gas, and electricity elsewhere taken for granted—and instead use firewood and crop waste for cooking and heating. Some 23 million Chinese have no access to electric power supply of any kind. Industry currently requires about two-thirds of all energy used in China, but this ratio is rapidly changing. As the country develops and narrows the income gap with the richer countries, more energy will be used in buildings and transportation.

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.

A diverse set of energy supply measures and economic reforms has helped reduce the share of coal in total Chinese primary energy consumption from 76 percent in 1990 to 66 percent in 2000. One significant effort toward this end is the government effort in the late 1990s to close illegal and small, economically irrational coal mines. By the end of the year 2000, the government had shut down some 47,000 small coal mines, producing 350 million tons of coal. The extent to which this success is real and can be sustained has been debated, but there is no denying that it has deeply affected the coal industry and cut coal use.[ii]

The government at the same time has increased exploration and development efforts for natural gas and has made significant discoveries in central and western China. Not long ago conventional wisdom held that China lacked significant supplies of natural gas and had to rely almost exclusively on coal. Yet, some 28 new large and medium scale gas fields are now under development. The city of Beijing has required the use of gas in place of coal in new fuel applications, a measure made possible by the 1997 completion of the

Shan-Jing gas pipeline from Shaanxi Province. A much larger step was taken in 2000 to help meet demand for high quality energy along the populous east coast by launching the "west-to-east" project, a 4,200 kilometer high pressure gas transmission line from Xinjiang Province in far western China to Shanghai, which is expected to be completed by 2007. The gas pipeline will supply 12 billion cubic meters per year (almost one-half exajoule, or one half-quadrillion BTU per year), and will substitute for over 20 million tons of coal annually. A new natural gas development project also was started in the East China Sea in 2000, and is expected to produce 10 billion cubic meters per year by 2010. In addition, a project to import liquefied natural gas (LNG) has been started with an initial annual target of importing 3 million tons.

Renewables, including wind power, photovoltaics, and biomass contribute small amounts of energy compared with mainstream energy supply and demand. Roughly, modern renewables—wind, biogas, and solar thermal and photovoltaic sources, as opposed to firewood, crop waste, and dung—contribute several million tons of coal equivalent annually. There is no reliable calculation of the emissions reduction by these sources because of the difficulty of comparing their effect with respect to some *status quo* baseline. For example, the government recently initiated a national program for photovoltaic power development with a total investment of over $US 200 million. Solar water heaters have expanded to a total of 26 million square meters of collection area, while accumulated photovoltaic modules exceed 15 megawatts and wind farms exceed 340 megawatts. Some 1,000 biogas tanks supply 600 million cubic meters of gas annually, and there are more than 1,300 geothermal developments, providing heat to more than 10 million square meters of living space along with 30 megawatts of power generation capacity.

Energy efficiency improvement and energy conservation are paid much attention in the energy development strategy in China. Since 1980s, China has formulated energy policy "Giving equal priority to energy exploitation and energy conservation", emphasizing the energy utilization in a sound and high efficiency manner and the improvement of energy efficiency. Since 1990s, energy conservation has been given the priority in energy policies.

High efficient and clean utilization of coal and other fossil energy is emphasized in the energy development strategy. The principle of developing clean coal technology is to improve coal utilization efficiency, reduce environmental pollution and promote economic development. High efficiency and clean technology plays very important role to reach low emission in China. Figure 5 shows an example in steel making industry for energy efficiency improvement and advanced technology diffusion.

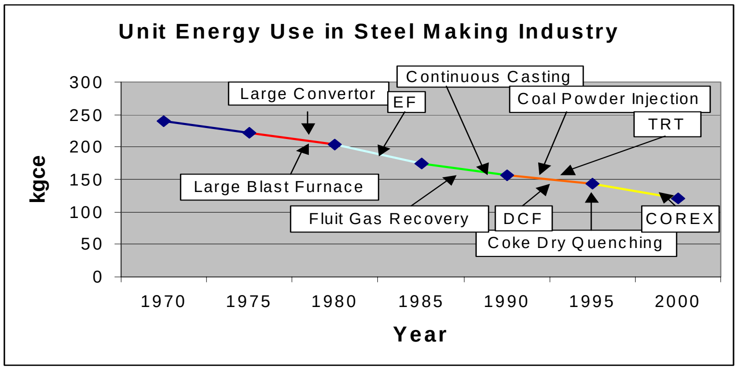

Figure 5 Technology progress and energy efficiency improvement in steel making industry

2.4 Food Supply in China

China is a big country with huge population, food sufficient is the vital basis for society stable and development. Currently, China arable land only cover about 10% of national land and per capita farmland of only 0.11 hectare which accounting for one third of world average (Wang CY, 2001). Therefore, Self-sufficient in grain is always the government struggle aim.

China grain production show steadily increase trend in general since the country established. In 1949, funding year of China, total grain production is only about 100 million tons. However, in the mid-1990s China grain emerged a huge burst of production increases and it reached about 500 million tons in 1998-1999s. From 2000 to 2002, China grain production has performed consecutive decrease trend and grain consumption exceeded production and the gap between grain output and consumption averaged 2.5 million to 3.5 million tons annually (Lu, 2003).

Table 3　China grain production from 1995－2002（million ton）

Year	1995	1996	1997	1998	1999	2000	2001	2002
Grain production	466.6	504.5	494.2	512.3	508.4	462.2	452.6	456.6

Source data: State Statistical Bureau. Include rough rice, wheat, coarse grains, tubers, beans and legumes.

Grain production decrease in recent three years (2000-2002) partly comes from that a growing number of farmers had switched grain to more cash crops such as fruits and fresh vegetables. But experts acknowledged that cultivated grain area decrease over the past three years did not mean that China's food security was threatened (Lu, 2003). China has historically kept large food grain stockpiles. The dual grain reserves of both the government and individual farmers helped ensure the food security. State Grain Stock ensure certain amount grain reserve and plays bridge role to maintain adequate food supply over grain lean year. Thanks to huge grain stocks, China's overall grain supplies still outstrip domestic demand.

Poultry, pork, egg annual production equals 11.8 million metric tons, 41.6 million metric tons and 377 billion pieces respectively. Though lower than the general level of the developed nations, China's average food grain and meat production per capita ranked above most of the developing countries, most food categories in China, including fruit, meat and aquatic products, but excluding dairy produce, had outpaced domestic demand and were produced for export (Lu, 2003). Meanwhile, there still exist small amount of specific grain foods that are imported from international market such as higher-quality wheat for processing purpose.

Soybean and vegetable oil is relative shortage compare with ever increasing demand. Edible oil consumption per capita in China has increased by 440 percent from 1979 to 1999. And it is project the soybean oil demand will increase over 4 percent annually (Kris Versdahl, 2002). The gap of the edible oil is 2.5 million tons to 3 million tons each year If it is assumed that every one possess 17 kilogram soybean (Lou YG, 2001).

Rice, wheat and corn used to be major staple food in China. Subsidiary grains include millet, oat, sweet potato etc. Generally, rice is the first staple food in China then follows by wheat. According grain production time trend in the recent twenty years (1981-2001), rice takes about 41.8% of total grain production, wheat and maize are 21.9% and 21.3% respectively. The rice dominant role is prominent than others, interesting change is between wheat and maize (figure 6). During the first ten year of concerned period, wheat production is always a bit more than maize; from 1990-1994, the two crop output was getting closely; but then onward, maize is higher than wheat slightly.

The wheat proportion difference with maize and its ratios in total grain production partly reflect China agricultural structure modified as put more attention to stock which prompt maize production. From 1990s, the consumption of meat increased rapidly, which caused an increase in the demand for feed grain, especially in 1995 and onward. In China, maize is the largest part to consume as feed stuff. The use of feed corn has been growing at 2 to 3 percent annually and approximately 55 million metric tons of the feed corn is used on-farm with a mix for swine and poultry feed (Kris Versdahl, 2003). While for wheat, it is exactly the same period that wheat production gradually dropped off as many society and natural environments changed. Now, the government encourages wheat cultivation from quantity to quality that makes traditional wheat production face new challenge and new management renovation.

From 1995 to 2000, the grain production has provided grain food per capita from 360 to 415 kg of which involves staple food consume, feeding stuff and grain industry et al. In recent year, economy fast development drives people income increase quickly. Demand of higher-quality, health, nutrition and safer food products grow rapidly. GM food is always argument point in the international food market. So far, it is not a major consumer issue in China. However, more and more consumers have become conscious to choose them and the government is attempting to develop regulation to control GM food supply.

Though China has made much progress on providing enough grain food for people, as with a noticeable number of needy farmers in outlying, mountainous areas in China's mid-western regions, food shortage among low-income families and individuals should be taken seriously in a bid to maintain food security of the entire country (Lu, 2003).

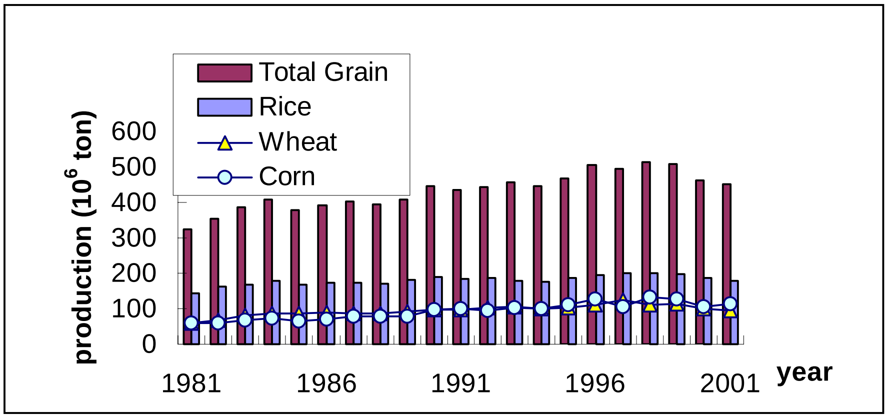

Figure 6 Total grain and major crop production time trend in China

Source data: State Statistical Bureau China and Foreign Agricultural Service USDA official data

2.5 Development goals

In terms of development goals, developing the economy and improving the living standard are the number one short- and long-term targets set out by the Chinese government. At same time sustainable development is recognised as an important issue. Agenda 21 for China, announced by the Chinese government in 1994, explicitly states that '*Taking the path of sustainable development is a choice China must make in order to ensure its future development in the century. Because China is a developing country, the goal of increasing social productivity, enhancing overall national strength and improving people's quality of life can not be realised without giving primacy…. At the same time, it will be necessary to conserve natural resources and to improve the environment, so that the country will see long-term, stable development.'*. Since 1994, Agenda 21's objectives have been translated into other policy plans, including the successive Five-Year plans. Other objectives include reducing the large differences in wealth in different areas (especially the rural areas and the regions in the west of the country), and hence to reduce poverty and to control population growth. The goal for energy is to supply enough energy for national economic development and ensuring environmental protection. Controlling urban air pollution is a major aspect of this.

2.6 National development trends

2.6.1 Social-Economic development

Recently new economic development target was given by Chinese government. It is 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 1500million by 2030. Scenario assumption for population from selected studies is shown in table 4.

Table 4 Population 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

Figure 7 gives GDP development trend presented by various studies. 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.

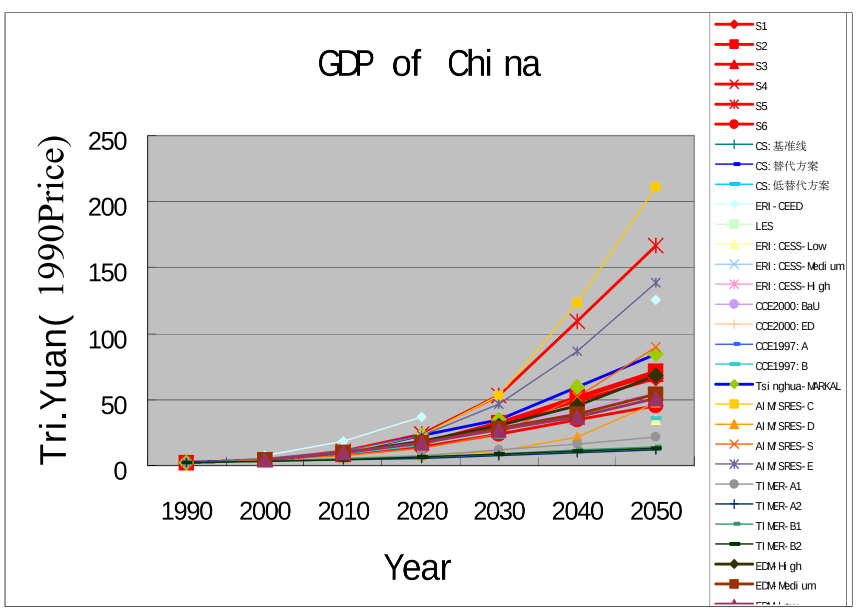

Figure 7 GDP scenario for China

2.6.2 Energy Development

There are several studies made analysis on future trend of energy demand and supply. Figure 8 shows the future energy demand in China. With the rapid economy growth, energy demand also keep very fast increase trend. Primary energy demand will increase to 1.4billion toe to 2.8billion toe in 2020 with a factor 2 to 4. By considering energy use bounded back to increase very fast in 2002, and most modelling study took year 2000 to be base year in which energy use went to lowest point for last several year, the future trend of energy demand may go to higher range.

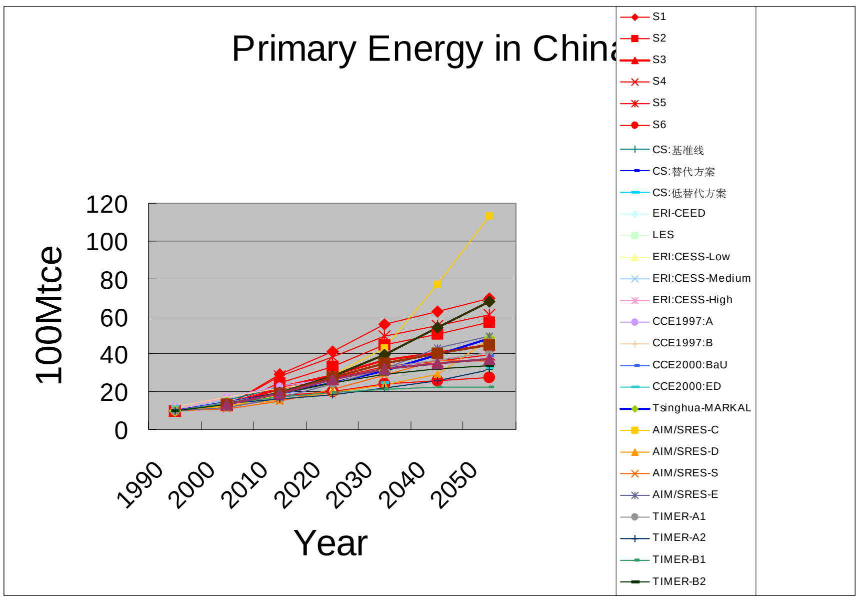

Figure 8 Energy demand scenario for China

2.6.3 Food sector

2.7 National policies

2.7.1 Overall social-economic policies

After beginning of 1980s, China started reforming and opening policies. Economic development became first concerning of government. In order to pursued economic development, following policies were adopted in China:

- Enterprise reforming. In order to promote competing and ability for production, enterprise reforming in state owned enterprise including change enterprise management pattern from government control to enterprise manager control system, separate enterprise management from government management, generally go to a modern enterprise system as enterprise in other countries.

- Encourage more private economy in China's economy system. Before 1980, state owned enterprise and collective owned enterprise dominated most enterprise in China. After the reforming and opening, private enterprise got legal right in the economy, more and more private economy appeared in China.
- Foreign investment and foreign enterprise was encouraged to enter to China. In order to promote more foreign investment, China opened some sectors for foreign investment to join and some financial incentives were given to foreign companies.
- Economic system rely on more law and national regulation rather than government control.

2.7.2 Energy policies

Historically China is a central planning nation, government instruction strongly affects energy activities. Reforming for energy industry restructure is undergoing now. Recently more and more policies and countermeasures have been announced to use standard and market based policies. Aim of these policies is to provide sufficient energy and high efficient energy industry to support economic development in China, in the same time take clean energy production and consumption to protect environment. These policies and countermeasures include:

- Energy efficiency planning. This planning is part of national Five-Year-Plan announced every five years. In the planning, energy use per industrial output value, unit energy use for major industry products and ability for energy conservation was set up; and some targets for rural energy production, requirement for energy conservation in sector and enterprise was given.
- Energy efficiency standards. Nearly 100 efficiency standard was announced by end of 1998, catalogue for machinery and electronic products including 1068 energy saving products and 610 products need to be disused was published.
- Price favourable for independent power plant investor. Price could be decided based on payback of loan and profit level.
- Tax derating for co-generation, energy saving building. Tax derating is given to wind turbine import, small hydro and biogass. No tax levy for wind farm in first two years in some province.
- Loan favourable for energy conservation project by different interest with average 30% lower.
- Price for energy saving by enterprise. Started from 1985, price is 8 to 10% of value by energy saving.
- Subsidy for energy saving stove in rural area, biogas promotion and city banquette production.
- Organize important energy conservation project by government including cement industry technology retrofit, fun and pump retrofit, World Bank/GEF project on energy conservation in China, green lighting, World Bank/GEF project on renewable energy commercialisation, forest energy project, pilot project of straw utilization, clean production plan, clean vehicle etc.
- Opening of energy price. Energy price could be decided by market and increased energy price could well contribute energy saving. Started from beginning of 1990,

energy price generally went to market based system from government control system. This give better situation for energy development. Now only energy use for some large power plants and residential users were controlled by government.
- Reforming on important energy industries. The administration system of China's oil industry has changed in correspondence with the historical transformation of the management mechanism of the oil companies. There are three major companies for oil and natural gas production in China. Power generation reforming is undergoing. Separating government function from power generation and change to companies management, separating power generation and distribution are the major activities for the reforming to provide competitive and opening power industry in China.

2.7.3 Agriculture policies

Agriculture is the foundation stone for China all economic sectors development, and farmer amount takes account about 70% of total national population. Chinese government has had its preliminary focus on food grain security at national level and regional level and has implemented series successful policies to promote agriculture development and improve farmer incentives. Such as Household Responsibility Systems, Reduced Scissors Gap, Grain Protective Price Policies, and Reduced Farmers Tax and Fee Pressure Policy, Increase Agriculture Input Policy, International border controls, Internal trade Restriction. etc.

- Household Responsibility Systems was adopted in 1978 as one part of society reformation. The system gave land use right to farmer households and all planting decision could be made by farmer themselves. It is proved that the policy was a great impetus to farmer production incentives so that Chinese agriculture experienced unprecedented fast growth from 1978 to 1984.
- Reduced Scissors Gap policy means to cut agricultural input material price and increase agricultural output price that return more benefits to farmers than commercial sectors.
- Grain Protection Price was provided by government that adjusted grain price more reasonable in order to keep farmer grain production incentives and assure national food security.
- Agricultural water available is always main focus for grain production, especially in Northern China. Recent years, government delivery Increase Agricultural Input Policy that invested large capital to construct water well and water channel in rural areas to mitigate ever-increasing agricultural water shortage situation.
- Green Standard: Chinese government now list green food, organic products, and non-polluting food industries as key priorities of agricultural development. Government officials recently announced to set up new regulations and give stricter management guideline on organic food market.
- Other local policies also provide more opportunity for agriculture sustainable development such as small loan support project.

2.8 Conflicts and constraints in meeting official development goals.

2.8.1 Energy Sector

Conflict to reach sustainable energy development goal:

- Coal based energy use caused serious air pollution problems. It is hard to shift to other clean energy in short period.
- Large amount of mining has bad impact on land use and water quality. Coal mining cause land collapse and underground water pollution.
- Fossil fuel combustion emits GHGs. This will have longer term impact on energy strategy.
- Because of domestic energy resource limitation, large amount of oil will be imported from international market, which will reduce domestic capital stock.
- Energy industry is a low profit sector which could not contribute well to economy development.
- Institutional structure is under reforming to provide a good environment for energy industry development, but answer is not clear.
- Limitation of clean energy resource. Energy data shows clean energy resource such as natural gas is quite limited in China.
- Weak ability to access to clean energy. Some regions in China already has economic ability to use high quality energy, but because of resource and infrastructure limitation, they still could not access to high quality energy.
- Poverty and energy. Still large number of people could not reach high quality energy. This appears not only for remote rural areas, but also in some region with scare energy resources such as in Shanxi province.
- China still takes some time to get into international energy market because of limitation of labour resource and capital.

2.8.2 Food Security

Key factors for the conflict and constraints may be considered as following:

- Scare and vulnerable natural resource base.China is a vast territory, but its arable land is quite limited. It is well known that China feed 22% of the world population by using 7% of the world total arable land, current arable land per capita is about 0.11 ha. Due to industrialization and urbanization, there is an increasing competition for limited arable land. Cropland per capita has decreased already. Even current farmland resource can be ensure, population increase, economy dramatic development and natural ecological environmental degradation all put tremendous further pressure on agricultural stable and development. China is one of the worst soil erosion and water losses countries in the world. At present, the total area subject to water loss and soil erosion in China has expanded to 3.67 million square kilometres, and annual soil loss by erosion exceeded 5 billion tons. The total decertified area in China has reached 2.62 million square kilometres and is still expanding with an annual rate of 2460 square kilometres. In Loess Plateau of northwest China, vegetation coverage ratio is only about 15%.

- Water shortage. In China, agriculture production depend highly on irrigation, and about 2/3 of agriculture output derives from irrigated land. Serious water shortage has become a major constraint to the sustainable development of China. Currently, more than 200 cities in China are threatened by water shortage, and annual shortage on irrigation reach 30 billions m3. Water resource distribution is quite uneven from south to north in China. In south China, water resource accounts for 81% of the whole county, however the cultivate land only are being about 36%, wile in north with 64% cultivated land, water resource are only 19% of national total.

  In west arid and semi-arid areas of China, the annual average precipitation is about 200mm while evaporation is above 1200mm, available water on agriculture is very limited; most crop productions depend on rainfall amount of growing season. At Changzhou of north China, water shortage drives people to over-exploit deep ground water, which make water table has fallen with 1-2 m annual from 1985-1997.

  It is estimate that the deficit water amount will be around 13 billion m3 in 2030 of whole China. Along with social development and people living standard improve, it is impossible to provide more water on agriculture, water shortage will be one of the most major constraints for future agricultural production. Varied water saving countermeasure have to be exploited, which is more urgently needed in China.

- Natural disaster. Chinese agriculture still lacks ability to defend natural disaster adverse impacts. Every year more than 200 million people are subjected to natural disasters and more than 20 million ha of crop are affected by natural disaster.

  During the 30 years from 1950 to 1980, the agricultural produce annually decreased by 20 billion kg on average due to all kinds of natural disasters and 5.3 billions of it come from drought (Wang CY, 2001). From 1950 to 2000, there was about 20.1 million ha of farmland influenced by drought and 9.3 million ha damaged by drought annually (Xu Zhifang, 2001). Annual average area suffering flood from 1950 to 1989 was 7.3 million ha of whole China, while during 1990-1993, it reached 15.3 million ha.

- Relative lower income and education level. Poverty problem still exist in some rural regions, which will drive relatively lower investment in agriculture input. On the other hand, low education level will make new or modern technology adoption face difficult.

- Regional disparity in agriculture development: As China is a large country, regional economic level and agricultural structure varies. With reformation and open-door policy implementation, the income differences between urban and rural, among farmers have appeared prominently. Disparity could also be observed on agriculture development among region location, eastern China is generally more wealthy than western.

2.9 Possible gaps to reach development goals

Sustainable development have been already setup as government long-term target. Various efforts were made to promote economic development when environment were concerned. There is significant progress for air pollution control like SO2 emission. However the overall air pollution is going worse with the rapid economic development. Many major cities are improving their air quality, but air quality in other regions is facing problems. State Environment Protection Administration made much effort to make regulation for pollutant emission. Some of them work well but some of them in other direction.

Following barriers are recognized to be the reason of the policies implementation difficulty in energy sector:

- High cost to implement the regulation. There some time high cost to implement emission control regulation, when
- Social difficulties. Some emission is from low income area where increasing income is the leading factor. Much more comprehensive policies should be developed for emission control.
- Low capacity to implement policies. Because of the low personal ability for administration and monitoring.
- Policies are not well-designed. Sometime the policies could not work well for the local condition to reach the target.
- Availability of clean technologies. In many case, advanced clean technologies are there but with high fixed cost, it is hard to be adopted by users in China.

Key question raised for energy development in China could be given as following:

- How to provide sufficient energy to support rapid growing economy and people life standard.
- How to solve the problem on environment impact during energy sector development, which is an important issue in China's energy development and sustainable development.
- How to established a well-development energy industry to support economy development in China.

For food security, major concerning includes:

- Long-term Land Use Plan: With a rapid population growth, more arable land will be needed to produce food. On the other hand, many croplands around city are shrinking and changing to be industry exploration zone as industry will take more economic benefit than agriculture. Balance land use between agricultural and other purpose should be combined into central or local government work plan.

- New technology dissemination: It is reported that if all current new technology have been adopted that grain yield can be improved about 1.5-3.0 times. While lack efficient operation standards and procedure, as well as incentive mechanism or suitable implementation pattern, new technologies are not well implemented and adopted in reality.
- Agriculture structures modify and cropping system optimize: Establish management mechanism on agriculture production, balance the ratios of living stock, grain, cash crop and feed material etc, arrange high-benefit crop according to market demand information, all these will promote agricultural sustainable development.
- National level support and coordinate: National macro steering, financial investment on science and technology revolution, and agricultural infrastructure construction like water-saving engineers programmer etc, all need substantial support on national level.

Strategic option for agriculture could include:

- Protect arable land and accelerate the transformation of medium-low yield field to high level.
- Further invest in medium and small water project construction, such as water collection well, water channel etc.
- Strengthen the capacity to resist natural disasters and improve the science and technology involvement in agricultural production.
- Further open up agriculture market and promote domestic and international agricultural enterprise to join in food processing, transformation and circulation

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3. Identification of Major indicators

In order to understand the future path for development and climate change, we need to identify some quantified data for the development. A group indicators were identified for the analysis. The indicators reflect the specific national development context and at the same time is in accordance with the generic indicators outlined in methodology report.

Following ways were used to identify these indicators:

- Selection of general indicators to be used in the national case study in accordance with global and regional context for the *Economic, Environmental, Human and Social* themes. This includes description of the general national policy background and the re
- Relationship to official plans and indicators. Specific indicators for the energy and food security sectors are considered.
- Definition and operationalisation of the indicators (quantitative and qualitative elements, standard for measurement).

By reviewing relative studies and development concerning in China, indicators for development and energy identified are given in table 5.

Table 5: Possible indicators to capture the development perspective in China

Issues	Key driving force	Possible indicators
Social development issues	GDP growth	GDP growth rate
		GDP per Capita
		Mix change of industries
		PPP index
		Population growth rate
		Education level
		Labour availability rate
Technology progress issues	Technology	R&D expenditure (as % of GDP)
		Technology level
		Foreign investment
		Foreign investments in climate change related technology and projects
		Number of collaborative foreign projects on climate change related technology development
Energy issues	energy availability	Indigenous energy resources used (as % of total energy used)
		Fossil fuel imports (as % of total value of imports)
		Per capita annual energy consumption (kg of oil equivalent)
		Per capita annual electricity consumption (kwh)
		Share of fossil fuel based electricity generation (as % of total electricity generated)
		Rural area electrification rate
		Energy efficiency improvement rate
		GHG emission from energy activities
		Local pollutant emission from energy activities
		Desulphurization rate
Food security issues	Agriculture, economy, population	Share of food in private final consumption expenditure
		Per capita calorie intake
		Population not using improved water resources (as % of total population)
		Population below US$ 1 a day
		Children underweight for age (% under age 5)
		Under nourished people (as % of total population)
		Low mother's body mass index (as % of female population)
Development policy issue		Share of rail traffic in freight transport (as % of total billion ton km)
		Share of rail traffic in passenger transport (as % of total billion passenger km)
		Railway route electrified (as % of total route km)
		Share of fossil fuel based electricity generation capacity (as % of total generation capacity)
		Coal based electricity generation capacity within 200 km of mine mouths (as % of total generation capacity)
		Average office commuting time in cities above one million population
		Waiting time for a new landline telephone connection
Employment indicators		National unemployment level
		Productivity of formal sectors (sector output/ employee)
		Productivity of informal sectors (sector output/ employee)

More specified indicators for energy and agriculture are given in table 6.

Table 6 Energy Sector Themes and Potential SD Indicators

	Themes	**Sectoral and Project Level Indicators**
Energy supply and consumption	Supply and demand including structure, efficiency, fuels, and costs	Energy balance Efficiency of conversion and end use (intensity index) Costs (per. energy unit)
Exhaustible resources	Non-renewable energy	Extraction and regeneration rates (e.g. biomass)
Environmental impacts	Climate change Air pollution Water Waste	CC vulnerability GHG emissions Air pollution Water pollution
Accessibility	Supply to business and households Transmission Other infrastructure Markets	Energy balance Transmission systems Markets: Structure, coverage, efficiency Informal markets Fuel wood collection
Affordability	Costs Investments	Cost measures Capital requirements and costs Energy expenditures relative to total production costs Energy expenditures relative to household expenditures for different income segments Time spent on energy provision
Health	Life expectancy Nutrition Epidemics	Life expectancy Infant mortality Major diseases
Education	Literacy rates Enrolment	Literacy rates Primary and secondary education (time, persons) Provision of light for reading Time for energy provision that substitutes education Skilled labour educated through energy management

The assessment of energy sector options can be conducted as an evaluation of the impacts of the option using selected SD indicators. The structure of the analysis should be to assess the difference between a baseline case and the implementation of desired options in terms of SD indicators and how this relates to the desired levels of development. This analysis can be illustrated by a case example, where the option considered is a rural biogas plants for household cooking, lighting, and electricity production. The following table 7 and table 8 give a qualitative overview of the impacts of the case example project.

Table 7 Illustrative Example of how the SD Impacts of Introducing a Biogas plant to Substitute Wood fuel and Kerosene Consumption can be Qualitatively assessed

SD Indicators	Biogas plant versus woodfuel and kerosene
Costs	Capital costs and O&M of biogass plant Replacement of costs of woodfuel onsumption and kerosene

	lamps
Energy access and affordability	Gas for cooking and lighting Electricity production for local industry (off grid) Most likely decreased energy costs
Employment	Employment of construction and maintenance staff Decreased employment for people related to woodfuel and kerosene supply
Environmental impacts	Biogass plant implies reduced local air pollution and GHG emissions
Education	Improved lighting facilitates reading Time savings due to reduced fuel collection enables children to increase school attendance
Income generation	Power for local industry increases business opportunities and thereby employment and income Households can supply more labour due to less time spend on fuel collection Decreased income of fuelwood and kerosene sector

Table 8 Food/water Sector Themes and Potential SD Indicators

Theme	Indicators
Economic Major products Secure quantity and diversity Essential nutrients Attractive quality of products Employment Profits	 Crops, meat Energy, proteins vitamins, fibres, fatty acids and metals Exterior & Interior No of people, income Monetary units
Environmental Safety of products Soil Water Air/climate Biodiversity GHG emissions/sequestration	 Toxic compounds, Toxic organisms Degradation, carbon loss & Accumulation of (potential) pollutants Quality/Leaching and run-off of pollutants Volatilisation of pollutants Flora/Fauna
Social Work & Livelihood strategy Well-being Education	 Number of people employed in/via agriculture, income levels, sharing of benefits. Quality of the environment including health Primary school attendance, training
Institutional Risk sharing institutions Finance Government instit. R&D Non - govern.	 Insurance coverage and turnover Loans, interest rates Number of persons employed Number of persons employed

4. Review of current plans and project initiatives

4.1 Energy

A preliminary planning for energy development was announced by government, power utilities and energy experts. Major points for the planning include: energy demand by 2030 could reach 1.96billion toe, power generation would reach 4.3TWh by 2020, in which coal fired power plant will take major role and would be more than 60% of total generation, hydro power will take around 15%, nuclear power could reach 40GW by 2020, gas fired power generation will reach capacity of 70GW, share 7% of total power generation, modern renewable energy power generation will have capacity of 15GW, share 1% of total power generation.

One of the basic principles of energy strategy is to supply enough energy for national economic development and the improvement of people's living standard. To ensure energy supply is one of the tasks for the China to the club of medium-developed countries by the middle of the next century with much lower per capita energy consumption than that of current developed countries. Because of China is in the period of rapid economy development, future trend of energy demand and production could have various possibilities.

4.2 Agriculture

According to National Economic and Social Development Plan and Long-term Target for the Year 2010, Chinese national strategy on agriculture development will involve following points. Increase domestic meat production and aquatic products by 10 million tons each; increase farmer income by 4% annually; stimulate agriculture sustainable development by regenerate of renewable resource or non-renewable resource limited exploitation; increase investment on agriculture and make it keep higher growth rate; change agriculture economic system form conventional pattern to market intervene.

In 1996, News Office of China State Council issued "Chinese Food White Book" which explicitly introduce China medium-long-term plan on food supply and demand. It is estimate that the population of China will increase to 1.4 and 1.6 billion in 2010 and 2030, the total grain demand projects to reach 0.55 and 0.64 billion tons if per capita supply of 390 and 400 kg are ensured at corresponding period. The target on self-sufficiency in grain of China's national policy is 95%.This means that to feed 1.6 billion populations in 2030, china had to increase the total agricultural product by 30%.

5. Positive Examples of Development and Climate Change Linkages

5.1 Contribution to GHG mitigation

Since 1980, China has obtained great achievement in energy conservation, of which 26% was from technical advancement, being around 157Mt. Most of this part was completed by industrial sector. During the recent 16 years, total construction investment for energy conservation reached 50 billion yuan. Total investment in technical retrofitting for energy conservation reached 16.6 billion yuan, of which 8.9 billion yuan was from national appropriation and loans, 7.7 billion yuan was raised by local government and enterprises, leading to an annual energy conservation capacity of 41.42Mtce.

With the support of national policies and capital, the foundation for developing new energy and renewable energy has been established in China. Compared to 1980, in 1996 the added energy supply capacity reached 9.09Mtce as the result of the development of above mentioned new and renewable energy. This has contributed to 20.06 Mt of carbon dioxide reduction.

The Chinese Government pays great attention to rural energy construction and has increased rural energy supply by spreading energy conservation technologies and developing new and renewable energy. The State has demonstrated and spread large scale engineering projects, such as primary electrified county dominated by small hydropower, major firewood county, major biogas county, pilot county of firewood-saving stove etc. Compared to 1980, in 1996, the development of new and renewable energy led to an energy supply of 16.82 Mtce. The added energy supply reached 40.97 Mtce, being equal to reducing carbon dioxide of 90.42 Mt.

The Chinese Government made effort to promote forestry development. Since 1990s, China has carried out a series of greening projects. At the same tine, different measures such as reforestation, forestation by air, forest conservation are adopted by national forestry centers, collective forestry centers. During the recent years, annual added forestation area reached 5 Mha, possession area of reforestation reached 34.25 Mha, percentage of forest cover increased by 0.2% every year. Compared with 1980, living forest increment increased by 2.515 billion m^3. If net carbon dioxide absorption is 0.96t from 1 m3 of living forest, total carbon dioxide absorption from forestry actions reached 2.414 billion ton during 1980~1996.

5.2 Example projects for development and climate change

5.2.1 Energy efficiency standard.

In order to promote energy efficiency improvement in China, China Certification Center for Energy Conservation Products(CECP) was established by former State Economy and Trade Commission in 1999. Major function of this center include: check quality management ability of enterprise , test main product performance and energy efficiency based on relevant standards and technical requirements; issue energy conservation product certificate; permit using energy conservation product label. Products for certification include Household Refrigerator, Room Air Conditioner, Color Television Broadcasting Receivers, Household Microwave Oven, Household Automatic Rice Cooker, Household Storage Water Heater, Ballast of Tubular Fluorescent Lamp, Ballast of High Pressure Sodium Lamp, Line Trap for AC Power System, Electric Power Fitting, Air Compressor Vocabulary-General, Three-Phase Induction Motor, Sitting WC Pan, Ceramic cartridge faucet, Power Saver. Up till now, CECP has issued certificates for about 800 product models from 70 enterprises or so.

Energy conservation certification speeds up energy efficiency technical advancement, 25.58% certified products meet EU requirements for A level at the end of 2001. Good economical and environmental benefits achieved from energy conservation certification, For example, accumulative economical and environmental benefits of household refrigerators are: 1.17billion KWh electricity saved, equipollent to 0.67 billion RMB (the calculated electricity price is 0.57 RMB/KWh); 0.396 million ton carbon reduced.

5.2.2 Green Lighting Project

The "China Green Lights Program" was a key energy conservation demonstration project organized and implemented by the State Economic and Trade Commission (SETC) during the "Ninth-Five-Year" Plan period. Aimed at energy conservation, environmental protection and lighting quality improvement, the project worked jointly with other 12 authorities such as State Development Planning Commission, Ministry of Science and Technology, Ministry of Construction, former China State Bureau of Quality and Technology Supervision, etc. In August 1996, the SETC document "Implementation Plan for China Green Lights Program" symbolized the formal start-up of this program. By completion in 2000, the program has achieved obvious social and economic benefits through the efforts of all relevant parties.

In order to consolidate the results and expand the experience obtained from "China Green Lights Program" and to further facilitate electricity savings and emissions reductions, as well as improve energy efficiency, SETC and UNDP jointly developed the new "SETC/UNDP/GEF China Green Lights Project".

This project will be implemented during "Tenth-Five-Year" plan from 2001 to 2005. In order to support the project, Global Environment Foundation (GEF) granted US$ 8.135 million; the Chinese Government, lighting industry, and related organizations will provide parallel financing when it is needed.

Main Activities and Outputs includes:

- Increase Supply of High-Quality Lighting Products by formulating the standards, and monitoring
- Create demand for energy efficient lighting products by raising awareness and understanding for consumers.
- Remove the market barriers of high efficient lighting products by demonstration and sustainable financing options.
- Achieve sustainable output by evaluation, facilitation and regulation

5.2.3 Wind Turbine Development Plan

By the end of 1999, China had over 20 grid-connected wind farm sites with a total installed capacity of 262 MW, and over 160,000 small wind turbines (50 to 5,000 W) with a combined off-grid capacity of 26.3 MW. There is an established domestic manufacturing base for small-scale wind turbines (50W-10kW) and emerging capacity to manufacture larger-scale turbines (>250kW). Recently a series of joint-venture companies have helped to bring the capacity to manufacture wind turbines suitable for grid-connection in-country.

In order to promote wind energy development, worked together by several ministries, a national project for wind turbine development was established. Major components include development of wind turbine manufacture and targeted installed capacity for grid connected wind turbine.

5.2.4 The Brightness Programme

Instigated by National Development and Reform Commission(NDRC), The Brightness Programme, is a large-scale rural electrification initiative stemming from the 1996 World Solar Summit. Over a period of 15 years, the programme aims to electrify 23 million people living in remote areas using wind, solar and hybrid technologies. Systems for individual households, villages, and remote stations will be installed, according to the most appropriate technology and the ability-to-pay of the beneficiaries. 86% of the cost of the systems will be covered by the beneficiaries, with the rest coming from local government (7%), central government (2%) and foreign grants (5%). The associated distribution and service networks will be wholly funded by grant financing. Following a piloting period, the first phase of the project (2000-2001) will connect 8 million people, 2000 villages, 100 border stations and 100 microwave stations to stand-alone renewable energy power supplies. The programme is already under implementation in Xinjiang (supported by $15 million from the Dutch Government) and plans to operate in Inner Mongolia, Gansu and Tibet.

5.2.5 Small Hydro development

Development of small-scale hydropower (installed capacity 16GW) has been the backbone of past rural electrification initiatives. The Small Hydro Power Programme, initiated by the State Council in 1983, was implemented by the Ministry of Water Resources in 100 counties without access to grid electricity. By 1989 the programme had installed 100W per capita in 88 of the program counties. In addition the Warm Spring Programme promotes micro-hydro (usually of less than 100kW) for several households and/or small businesses.

5.2.6 Promotion of natural gas penetration

Because of local air pollution problem, many cities and provinces started to make regulation to use more clean energy especially natural gas. Such as in Beijing, regulation is set up as no more coal use within third ring road which cover major part of the city. Natural gas is a major energy to replace coal in Beijing. In the mean time, Beijing government invested to construct second natural pipeline from natural gas field in Inner Mongolia to Beijing, which give natural gas capacity as 5 billion cubic meter for next 20 years. Many other cities made similar decision in order to improve local air quality.

In China as whole, provide more natural gas to consumers is a key energy strategy in recent years. Much more investment was taken for natural gas exploration and exploitation. A very big project named as “Transport natural gas from western China to eastern China” was lunched in 2001. And the pipeline from Xing Jiang to Shanghai is under construction and will provide natural to Shanghai by 2004.

5.2.7 Development of public transport system

Because China is experiencing rapid economy growth, many large cities is facing transport pressure. Quick development of urban transport already caused local environment problems including air pollution problem and noise problem. In order to release the pressure, many cities in China are taking public transport development as first priority in urban transport development. Here we take Beijing as en example.

Beijing is the capital city in China and GDP per capita is around US$2500(exchange rate based). In last decade annual average GDP growth rate is higher than 10%. However in 1997 Beijing is one of the cities with worst air pollution in the world. Much efforts were taking from government to control local air pollution. Development of public transport is one of the efforts. In the last decade, the share of public transport in passenger capacity tended to drop gradually because of strong trend on private car purchasing, as showing by table 9. The length of rail-based mass rapid transport system (MRTS) was only 44 kilometres in 1998 and 56 kilometres in 2001, much lower than that in similar international cities, such as Paris, Seoul, Tokyo, Moscow and New York By contrast, personal transport was developing by a rapid growth rate. Up to 2001, the share of private automobiles in total vehicle stock has been amount to 67.9%, increasing by an average growth rate of 21% when compared with that in 1995. Rapid growth of private transport has been caused many problems, such as low transport efficiency, congestion and bad pollution.

Table 9 Mix of transport demand in Beijing

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Public transport (%)	48.21	46.90	43.13	36.44	34.42	33.59	33.76	33.55	34.68
In which: MRTS	5.22	4.79	5.03	5.08	4.94	4.80	6.38	5.73	5.77
Personal transport (%)	51.79	53.10	56.87	63.56	65.58	66.41	66.24	66.45	65.32

Note: public transport refers to transit bus and subway; personal transport refers to private vehicles, bicycles, vehicles owned by social organizations and companies.
Source: Jiang, etc, 2002.

The serious problems are mainly caused by rapid growth of personal transport and slow development of public transport, especially of MRTS. Up to the year of 1998, the length of rail-based mass rapid transport system (MRTS) was only 44 kilometres, much lower than that in similar international cities, such as Paris, Seoul, Tokyo, Moscow and New York. In view of the growing passenger travel demand, low efficiency of current transportation mode, and strict environmental requirement, Beijing government decided to take great effort to develop bus system and MRTS in the new century.

Beijing government make huge plan for public transport development. In the next 10 years, rail track line would increase by 40 km/y with investment of over 10 billion RMB every year. Before 2008 Olympic Game, 8 new MRTS routes would be constructed, see details in table 10. Up to 2008, the total length of subway in downtown area would be about 250 kilometres. Together with MRTS in suburb, total length will be amount to 300km.

Table 10 Planned MRT lines in Beijing before 2008

Name of the subway routes	Length (km)	Status in quo

No.1 & No.2	56	In service
No.13	40.5	Operation since Jan. 2003
No.4	27.6	Under construction**[n1]**
Ba-tong Line	19	Under construction
No.10	23.9	Under design
Olympic line	4.0	Under design
Yizhuang line/No.5	26	Under construction
Airport line	22.0	Under design
No. 9	5.8	Under design
Total	251	

Development plan for public transport system is described as following:

- Up to the end of 2020, build 20 subway lines in downtown area, totally 700 kilometres.
- Build 360 kilometres MRTS to link the central downtown with the 14 satellite towns located within outskirt and exurb of the city, including light rails, suburb railways, tram rails, and magnetic suspension railways.
- For non rail-based public transport system, the focus in next seven years would be the optimisation of transportation network. Taking downtown as centre and radiate to suburbs and residential area, the finial network would be very reasonable, rapid and convenient.
- Up to 2008, the vehicle stock of transit buses would be 18 thousand (now it is about 10 thousand) and public transport lines would be 650.
- A easy-taking public transport system will be established. Transfer distance between two bus lines will not more than 150meter. Within second ring road a subway station will be reach within five minutes walk.
- In order to encourage people to use public transport system, more convenient way will be used including monthly ticket, electronic card ticket etc. Countermeasures such as very high parking fee for cars within third ring road will be adopted to limit car use.

According to the study done by ERI(Jiang etc, 2002), much GHG emission and local air pollutant will be mitigated by extending public transport system.

5.2.8 High energy efficiency technology and clean energy development

Technology play key role in climate change mitigation shown in several studies[IPCC, 1996,2001; Jiang et al, 1998]. As a large country at the stage for economy to take off, technologies are very important in the sake of energy, environment and climate change. Technology progress play key role in GHG emission reduction in China, while most of these technologies are also match the demand for energy conservation and environment both in short-term and long-term. Therefore technology strategy could well combined with energy and environment policies. Detailed technology studies on sector level to reduce CO2 emission show well match with technology progress desired by sectors without consideration on climate change (see table 11)[Hu et al, 1996, Jiang et al, 1998]. Various national policies and sector based policies were made to promote these technology's diffusion.

Table 11 Technologies contributing to GHG emission reduction in short and medium-term

Sector	Technologies
Steel Industry	Large size equipment (Coke Oven, Blast furnace, Basic oxygen furnace ,etc.), Equipment of coke dry quenching, Continuous casting machine, TRT Continuous rolling machine, Equipment of coke oven gas, OH gas and BOF gas recovery , DC-electric arc furnace
Chemical Industry	Large size equipment for Chemical Production, Waste Heat Recover System, Ion membrane technology, Existing Technology Improving
Paper Making	Co-generation System, facilities of residue heat utilization, Black liquor recovery system, Continuous distillation system
Textile	Co-generation System, Shuttleless loom, High Speed Printing and Dyeing
Non-ferrous metal	Reverberator furnace, Waste Heat Recover System, QSL for lead and zinc production
Building Materials	dry process rotary kiln with pre-calciner, Electric power generator with residue heat, Colburn process, Hoffman kiln, Tunnel kiln
Machinery	High speed cutting, Electric-hydraulic hammer, Heat Preservation Furnace
Residential	Cooking by gas, Centralized Space Heating System, Energy Saving Electric Appliance, High Efficient Lighting
Service	Centralized Space Heating System, Centralized Cooling Heating System, Co-generation System, Energy Saving Electric Appliance, High Efficient Lighting
Transport	Diesel truck, Low Energy Use Car, Electric Car, Natural Gas Car, Electric Railway Locomotives
Common Use Technology	High Efficiency Boiler, FCB Technology, High Efficiency Electric Motor Speed Adjustable Motor, Centrifugal Electric Fun, Energy Saving Lighting

Many of these technologies already appeared in sector development plan made by government or enterprise. What we should do is to further prompt development of these technologies by including climate change as a factor to raise the demand for these technologies.

Basically these technologies also in the list for government to think about except unconventional energy technologies. Because of lack of investment on technology R&D, most of these technologies are expected to be developed in other countries. Development of these technologies is common requirement by all of the world. However some of the technologies could be made more investment in China for R&D. For example, IGCC and clean coal technologies have large potential market in domestic while it is uncertain to look for market for technology developer in country with small coal use. If China can be leader on development of these technologies, benefit could be obtained from both environment and economic development. In such case, policy for technology development could be revised by consideration of climate change. International collaboration on development of these technologies is necessary.

5.2.9 863 High Technology Development Plan

The National High Technology Research and Development Program (863 Program) was launched in March 1986 with the aim of enhancing China's international competitiveness and improving China's overall capability of R&D in high technology. The Program covers 20 subject topics selected from eight priority areas: Biotechnology, Information, Automation, Energy, Advanced Materials, Marine, Space and Laser. The first six areas are managed by the Ministry of Science and Technology (MOST) of the People's Republic of China. In the program, there are several key energy technologies. Following is the major progress for energy technologies:

● High Temperature Gas-Cooled Test Reactor, a major project in the field of energy technology, has completed its civil engineering construction and entered the last stage: integral assembling, test and debugging. Besides, the following have been achieved: the manufacturing and assembling of most of the key parts of the "nuclear island" and "conventional island"; the drafting of technical documents such as the Debugging Program, and the engineering experimental tests on the majority of key systems; the successful development of fuel samples for irradiation; and study on two-phase flow stability within the once-through steam generator.

● The Experimental Fast Neutron Reactor Project has entered the engineering preparation stage. The design of a construction map taking into consideration civil engineering construction and the ordering of large-sized non-standard equipment has been made. The construction site is ready for use, important progress has been achieved in the test of design validation, and review on nuclear safety as part of the work included in the initial safety analysis report will be completed soon.

● The Fusion/Fission Hybrid Reactor Project has completed the following: improvement of the windows, transmission system and control part of the HT-7 lower-hybrid wave, debugging of the entire system, long-pulse operation at 1 mw/s on water load, design of solutions for a 3MW neutral beam injection system at HL-1M and pre-study of key techniques.

● The Coal-Fired MHD Power Generating Technology Project has completed the designing and manufacturing of a helical electrical MHD propeller used for conducting performance test of the high field superconducting electrical MHD propeller. Through international cooperation, the performance test of a 15-tesla high field helical closed-loop electrical MHD propeller was conducted successfully, the actual field intensity being 14 teslas. Besides, a 700A electrode current and 9.3-14% propeller efficiency were achieved under the high field condition.

5.2.10 Forest Development

Since China starts its reform and open-door policy, the government has put great strength to forestry development and eco-environmental construction. Currently, the forestry coverage of whole country had increased to 16.55%; total area of plantations has reached more than 46 million ha and ranks the first in the world. Nevertheless, the average forestry area per capita is only 0.128 ha, accounting for only 21.3% of the world average (Jiang ZH, 2001).

Many key and large forestry engineer programmers have been launched, which involve three northern forestry construction programmer, afforestation programmer, natural forestry protection programmer, desertification prevention programmer et al.

All these input more incentive on forestry development, but it is still far away to meet the social sustainable requirement. As China government take “sustainable development” as her basic national policy, in 2001 the Sate Forestry Administration has given priority to forestry ecological environment construction in the long-term work plan, stress the importance and necessity of construction of forestry ecological network system.

The forest ecological system establishment is to protect the existing forest resource, improve forest quality, and expand forest coverage. But the ultimate goal is to control water and soil loss by erosion, desertification and sand formation, hence reduce wind and sand storm, natural disaster of drought and flood, typhoon and tide etc, further provide a safe, health and sustainable living space to Chinese people.

5.2.11 Returning to forest from agriculture land use

Land use change in **China** is related closely to environmental change and food security. The total area in cereals increased or remained unchanged during 1961-1978, a period when the "Cultural Revolution" occurred, and also increased during 1986-1990 when the Chinese government increased subsides to agriculture. However, the total area in cereals declined during 1980-1985, a period corresponding to the implementation of the "household responsibility system" policy, and during 1991-1995, when a large proportion of the rural labor force moved to urban areas. It could be see that arable land change majority from society disturbance, never consider ecosystem natural law.

Soil and water loss and land desertification continues due to natural resource over exploitation in many areas of China. As intensive agriculture has been developed at the cost of ecosystems, as return, worsen ecosystem put much constraints on agriculture practice, especially in Northwest regions. As a result, considerable attention is being given to addressing these problems. By 1997, China had planted over 10 billion trees and in 1999 the increased forest coverage to 16%. Recently government issued “return arable land to forestry” policy to encourage people return much low-yield land to forestry in order to recover ecosystem. At the same time, the circular of the State Council on Policies and Measures Pertaining to the Development of the Western Region includes *strengthening environmental protection and ecological improvement*, in the priority tasks for the present and near future.

6. Assessment of analytical tools – SRES scenarios and modeling approaches

With the progress of scientific knowledge on climate change, it is clearly recognized that efforts must be made to reduce GHG emissions. The international negotiation process recently secured a remarkable achievement when agreement on the Kyoto Protocol was reached at the Third Session of the Conference of the Parties (COP3) to the United Nations Framework Convention on Climate Change (UNFCCC). A timetable was announced at COP4 for the key issues in the Kyoto Protocol. The international negotiation progress has heightened the demand for climate change research. This demand is particularly urgent for developing countries including China. Comprehensive studies need to be conducted to gain perspectives on future climate change. Such efforts are essential in order to understand the possible directions of climate change. Long-term GHG emission scenarios play a key role in these studies.

The IS92 scenarios published by IPCC in 1992 (Alcamo, *et al*. 1995, p251) supported related research and policy-making processes. In 1994, IPCC published a special report to evaluate the IS92 emission scenarios. The report summarizes the objectives of emission scenarios as follows. First, as input for evaluating the environmental/climatic consequences of non-intervention, i.e., no action to reduce GHG emissions. Second, as input for evaluating the environmental/climatic consequences of intervention to reduce GHG emissions. Third, as input for examining the feasibility and costs of mitigating GHGs from different regions and economic sectors, as well as over time. This objective can include setting emission reduction targets and developing scenarios to reach these targets. It can also include examining the driving forces of emissions and sinks to identify which of these forces can be influenced by policies. And fourth, as input for negotiating possible emission reductions for different countries and geographic regions.

Many long-term emission scenarios have been published to date (Matsuoka et al. 1996; Morita et al. 1994; Alcamo et al.1995, p272; Edmonds et al. 1995). In this regard, some arguments have also been presented by experts from developing countries (Parikh, 1992; Zhou et al, 1997). The major argument is that developing countries' viewpoints have not been reflected fully in these scenario studies. Most of the scenarios were developed by research teams in developed countries, with the result that much more attention was given to developed countries in those studies. There is also a lack of information on developing countries. One of the objectives of our study on emission scenarios for China is to improve understanding of emission scenarios in the developing countries.

The present study was motivated by the development of the new IPCC emission scenarios. Scientific knowledge concerning climate change has progressed over the past several years, and IPCC decided to develop a new set of reference emission scenarios which were reported in an IPCC Special Report.

The studies on scenarios for China published so far were reviewed by retrieving data from an emission database developed by Prof.. Morita and from other reports. The ranges of these scenarios are quite large (see Figure 9). The wide ranges mainly reflect the characteristics of the input data.

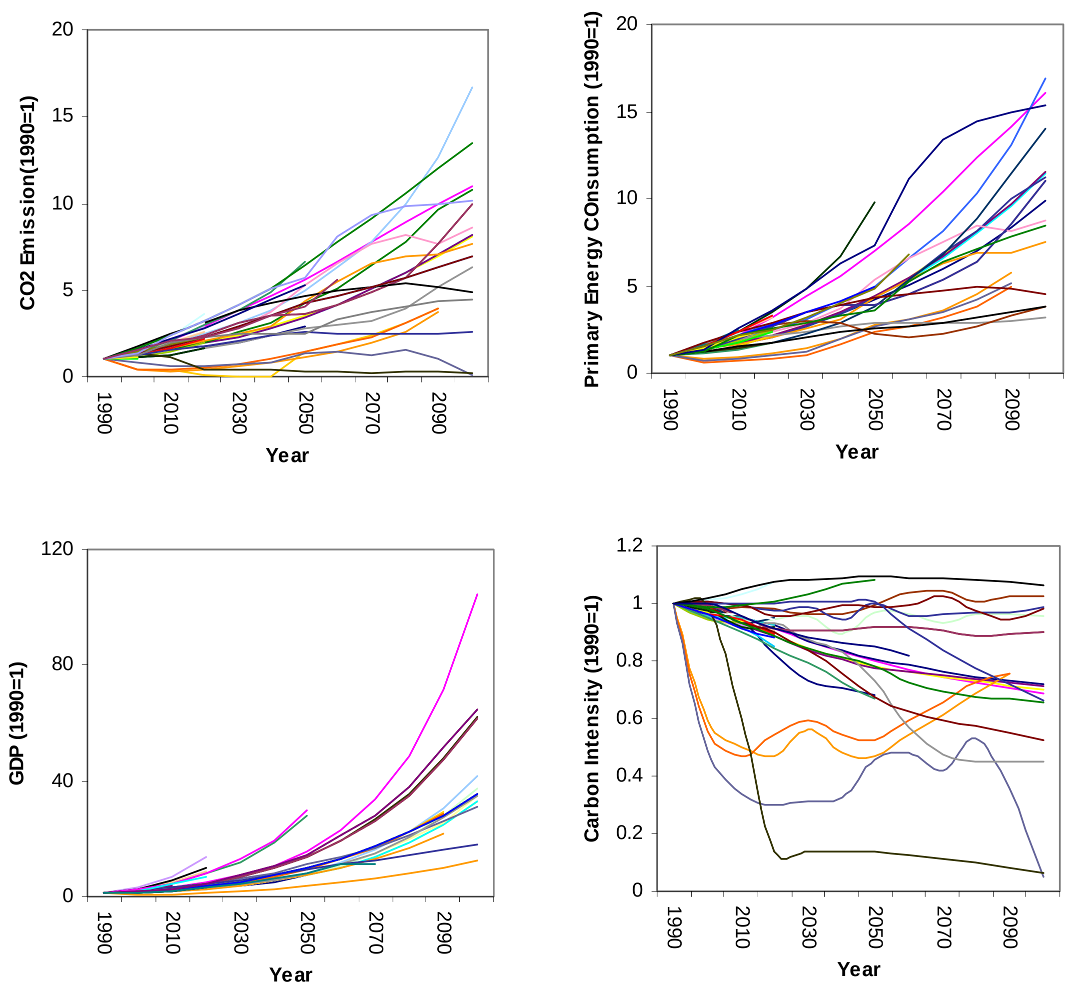

Figure 9 Ranges of selected scenarios for China

An analysis of the selected scenarios for China was undertaken by Zhou (Zhou *et al*.1997; Hu *et al*. 1996). From this analysis, some gaps were found between the key assumptions for these scenarios and the recent pattern of development. Hence, a more regional development perspective should be reflected in future scenario studies.

7. Assessment of analytical tools and approaches

7.1 Energy sector

In order to quantify the results for this study, a modelling tool named Integrated Policy Assessment Model for China(IPAC model) is recommended to be used. IPAC model a model framework which includes several different models focusing on various policy assessment. Figure 10 gives the structure of IPAC and policy questions answer by these models. IPAC model were developed by several international collaboration studies including collaboration with AIM team in National Institute for Environment Studies(NIES) in Japan, SGM team in Pacific Northwest National Laboratory(PNNL) in United State, IMAGE team from National Institute for Environment and Public Health(RIVM). And some model were developed by our team.

In this study, IPAC-Emission model and IPAC-AIM/Technology model will be used for the policy simulation.

IPAC-Emission model was developed for emission scenario study. It links several models to calibrate the data and perform scenario quantification. An important point is that China's development pattern should be analyzed under the global context because international situation will strongly influence the country's future environment, economy, and energy activities. Scenarios for China should also be closely related to the scenarios for other regions. Hence, the model framework adopted was a global model divided into 9 regions including China (CPA), United States (US), Pacific OECD (OECD-P), Europe OECD + Canada (OECD-W), Eastern Europe and Former Soviet Union (EFSU), other Asia (S.E.Asia), Middle East (ME), Africa, Latin America (LA).

Major emission sources including energy activities, industries, land use, agriculture, and forests, can be simulated in the model framework.

The components of IPAC-Emission model framework were adopted from previous studies(see figure 11).

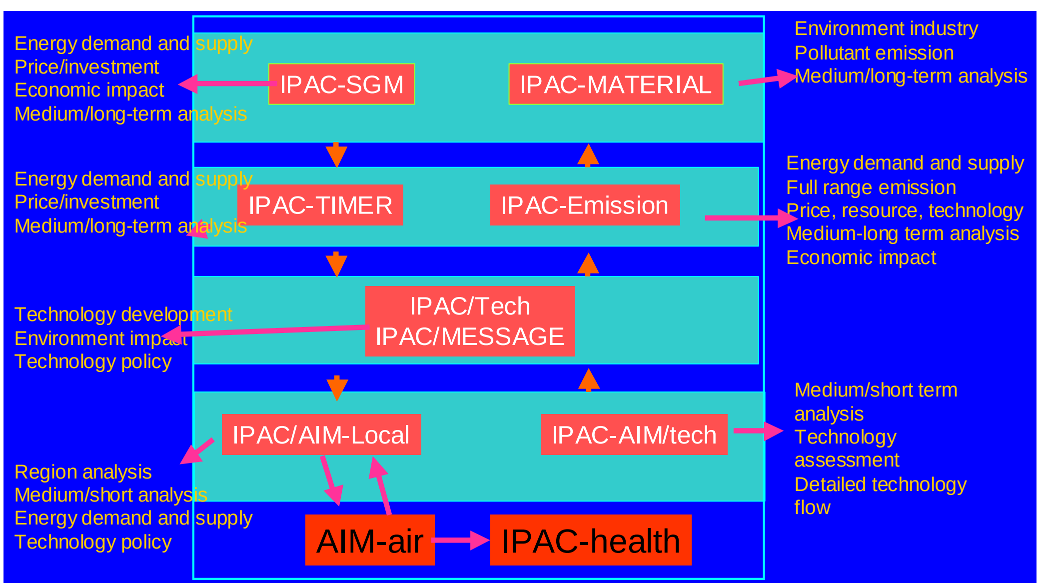

Figure 10 IPAC model framework

IPAC-AIM/Technology model is developed from AIM/end-use model and becomes its Chinese version. It consists of a flow from energy service demand to technology selection then to energy demand. First energy service demand is estimated through useful energy demands, which will need to be met by energy service (given as exogenous). Then various energy service technologies are selected based on least cost and policy constrains. Cost for technology includes fixed cost, operation cost (energy cost and other cost such as labor and material cost etc). Energy demand is calculated from technology penetration.

According to the current statistical system of China's national economy as well as the data availability, energy end users in this study are divided into five sectors, i.e., industrial, agricultural, service, residential and transport sectors. Every sector is broken down into several sub-sectors or products, or service categories. For industry sector, sub-sectors are categorized and then every sub-sector is divided into one or more products. For transport sector, under every sub-sector, transport is categorized as passenger transport and freight transport. For residential sector it splits into urban and rural sub-sector to match with their different development pattern. Energy service and technology selection for each sector or product are determined so that energy consumption and CO2 emission can be estimated. The IPAC-AIM/Technology model covers 26 sectors and more than 400 technologies.

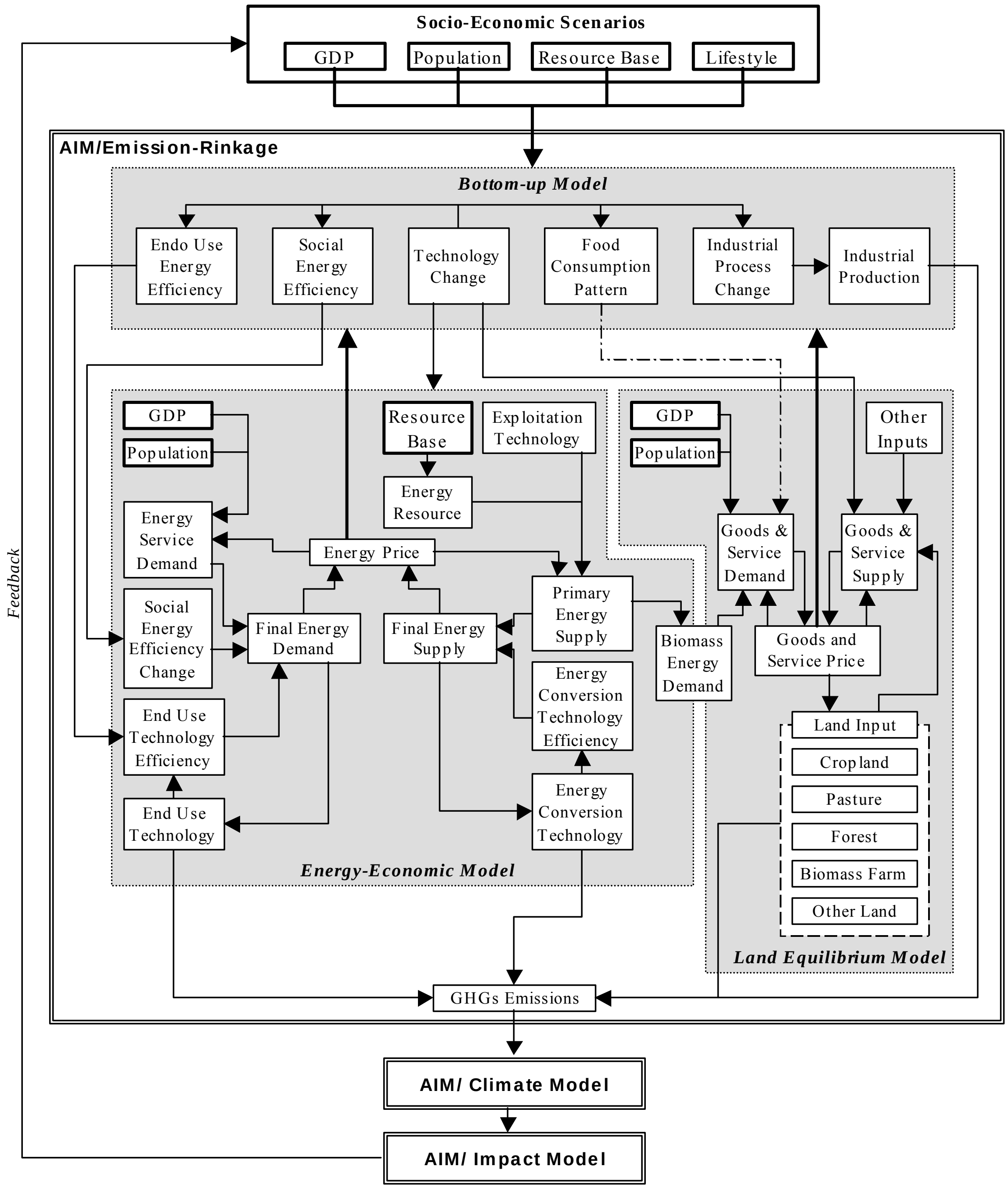

Figure 11 Framework of IPAC-Emission model

7.2 Food security sector

In this project, Decision Support System for Agro-technology Transfer (DSSAT) version 3.5 is selected to predict grain production under climate change scenarios. DSSAT is an integrated software system that simulates crop production and water requirements in response to weather, soil conditions, and management practices (Tsuji, 1994). CERES series are one module in DSSAT and cover Rice, Wheat, Corn etc crops. The model has simple structure, a good deal of function and the friendly interface. It can simulate the crop yield with irrigation and without irrigation, and can simulate the growth stage and organic development of different crop variety under different climate condition. It consists of four sub-programs: soil-water sub-program, nitrogen balance sub-program, photosynthesis sub-program and crop growth sub-program. Besides, it has some other parts, such as the calendar conversion assist-program, the print output assist-program and so on.

DSSAT is a process-based, management-oriented model simulating the growth and development of crops. It has been relatively well tested in a range of environments. The model operates on a daily time steps, and requires values of daily solar radiation, maximum and minimum temperatures, and precipitation as inputs. Phenological stages simulated include sowing, germination, emergence, juvenile period, floral initiation, anthesis, beginning of grain fill, end of grain fill, and physiological maturity. The rate of progression through these stages is dependent on the temperature and genotype, and additionally on photoperiod during floral induction from the end of the juvenile period to the start of floral initiation. Daily biomass production is calculated as a function of leaf area index (LAI), incident solar radiation, and a radiation use efficiency constant, but can be reduced by high temperatures and nitrogen deficit. LAI is a function of leaf numbers and leaf size, both of which are dependent on the rates of leaf appearance and expansion respectively. These rates can also be reduced by water and nitrogen deficits. Allocation to the various plant components of the biomass produced each day depends on the phenological stage of the plant, and can be altered by water and nutrient deficiencies. As the model is capable of using different environmental and management information within a growing season or for different seasons in a single model execution, it can therefore simulate different management options, assess crop responses to irrigation and rain fed systems, and estimate potential alternative tactics under climate change conditions.

Historical weather data come from China national network of meteorological stations. Some stations did not include solar radiation values (MJ m^{-2} d^{-1}), so these were calculated from recorded sunshine hours using the Angstrom formula, with the coefficients being determined according to geographic location (i.e. longitude and latitude) based on China previous research (Wang YX, 1981). Future climate change scenarios were provided by the PRECIS (Providing Regional Climate for Impacts Studies) model which was developed by the U.K. Hadley Centre. Previous research indicates that PRECIS is able to simulate the present climate over China well in terms of solar radiation, temperature and precipitation (Xu, 2003), and is, therefore, suitable for linking to a crop simulation model.

The minimum set of soil data required is: soil pH, organic carbon, cation exchange capacity, and exchange amount of Ca, Mg and K, bulk density, total porosity, available water content, percentage sand, silt and clay content, and upper and lower limits of volumetric water content. Values for most of these parameters were extracted from the China Soil Investigation Book 1990 according to soil distribution, vegetation type, and area, while some, such as available soil water content, were obtained from the FAO soil database.

Using long term observed records from agricultural experiment stations all over China, extract crop management patterns, which included the date of sowing, the fertilization, irrigation regime and yield component, etc.

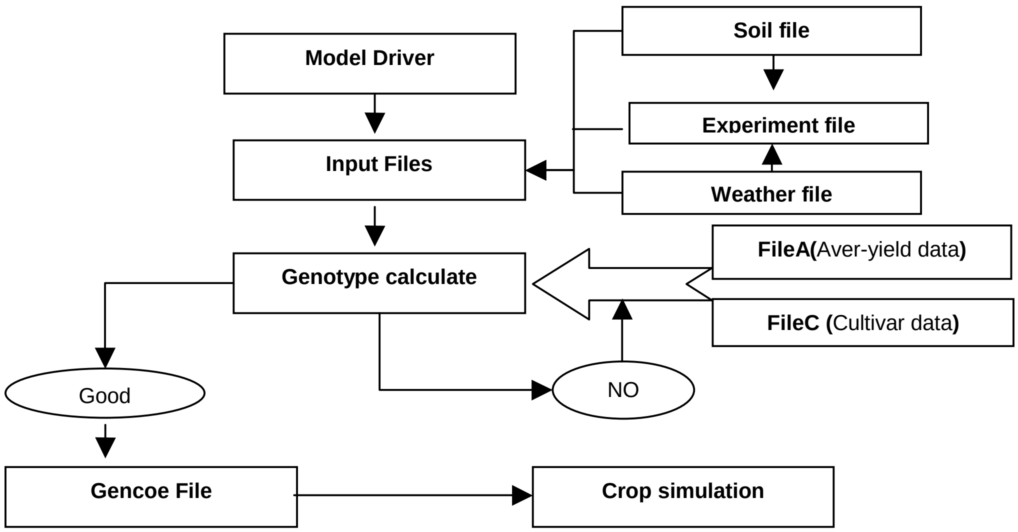

Figure **12 Framework of DSSAT model**

8. Identification of actors, stakeholders, and the civil society

The study will involve the following stakeholders:

- Government:
    - SEPA(State Environment Protection Administration). Major environment administration agency in China focusing on domestic environment issues.
    - NDRC(National Development and Reform Commission). Response for national development plan, energy policies and work with other ministry for environment policies.
    - MOST(Ministry of Science and Technology). Major policy maker for technology development in China, and correspond for technology collaboration.
    - MOF(Ministry of Finance). Administritor for international government collaboration and domestic government budget, including government oriented research.
    - MOA(Ministry of Agriculture). Administration for agriculture production, rural energy and small hydro utilization.
    - MOFA(Ministry of Foreign Affairs). Negotiation for climate change.
    - Chongqing Development and Reform Commission. Economy development, energy and agriculture development planning, and policy making, playing key role in local development issues.
    - Ningxia Science and Technology Commission. Policy makers from Ningxia province, one of the provinces in western region in China.

- Beijing Science and Technology Commission. Regional policy makers for technology development, and also energy issues.

- Industry & agriculture
  - State Power. One of major power generation companies in China. So far still take some government function on electricity power administration.
  - China Petroleum and Natural Gas Co. One of the three major companies for oil and natural gas.
  - Energy Conservation Investment Co. mainly working on energy conservation investment, a very important player for energy investment.
  - Haerbin Boiler Manufacture Company. One of biggest producer for boiler in China.
  - Jinghua Bus Manufacture Company. One of biggest bus manufacture in China. Play important role in clean bus manufacture including natural gas buses and LPG buses. Their products have big impact on clean urban transport system.

- NGOs
  - China Energy Association. Expert group for energy policies and countermeasures analysis in China. Technical supporter for government policy making process.
  - China Building Material Association. Expert group on building material industry development. Technical supporter for government policy making process.
  - China Energy Conservation Certification Centre. Newly established certification centre for energy conservation products and now work well, contributed to energy technology progress in China.

- Researcher
  - Tsinghua University, research team on energy and climate change issues, important research supporter for policy making process.
  - Beijing University.
  - Beijing Renming University
  - Chinese Academy for Science
  - Chinese Academy for Social Science
  - Chinese Academy for Agriculture
  - Chinese Academy for Forest
  - Energy Research Institute

9. Overview of relevant national decision making processes in China

In China, Both state government and local government(provincial government and city level government) play major role in policy making process. Even through China is establishing a market based economy system, government still play more important role on policy making process than that in other countries. Brief framework for policy making system is described as following.

Energy

- National government. Major functions were assigned to:
    - Energy Bureau in National Development and Reform Commission (NDRC), administration on overall energy related issues including coal industry, oil and natural gas industry, power generation industry, and energy conservation and renewable energy utilization.
    - Resource Utilization Department in NDRC. More focus on energy conservation. Make plan and relative policies on energy use nd conservation.
    - Energy division in other ministries including Ministry of Agriculture, Ministry of Transport, administration on rural energy including agriculture energy use and household energy use.

- Companies that play role of government. During the process of enterprise reforming, some large state owned energy companies still play some role as government, such as State Power, Petro-China.

- Local government. In province level there are similar government structure and process with central government. Provincial government has right to make local policies for energy and other economic activities. Provincial government almost has same department like ministry in central government and take similar function.

Agriculture

- National government

- Agricultural Economy Department in NDRC. Formulate agricultural policy at national level, and determine agriculture development direction and emphasis, then recommend to State Council.
- Industry Structure and Legislation Department in MOA. Design and formulate agricultural industry structure. Coordinate and implement agricultural policy, and agricultural economic development strategies.
- Development and Plan Department in MOA. Design agriculture production distribution, implement agriculture development plan.
- Planting Management Department in MOA. Determine planting plan and design planting structure.

Company or Enterprise

- State Administration for Grain Reserves (SAGR) constructs the national grain balance sheets and manages the central government's strategic grain reserves.
- Grain Bureaus arrange domestic marketing of grains at the provincial, prefecture, and county levels based on national plans prepared by SAGR.

Local government

- Agricultural Economic Division of Chongqing Development and Reform Commission. Formulate local agricultural development strategies and policy.
- Chongqing Agricultural Administration. Administrate local agriculture practice and implement development plan.

10. Preparing the dialogue

10.1 Application of proposed overall process design for country study

Following process for dialogue was used in country study for China

- Identify possible stakeholders by following criteria in the methodology document. As reported in above sessions, a group of stakeholder was identified.
- Meeting with key policy makers and researchers in the project proposal period, to report the basic idea for the study and get comment from the meeting. Two meetings were held for the project, one in the beginning of phase one country study for China, the other one held for the proposal design on Chongqing study.
- Involve the discussion by stakeholders for the key issues in the study by project meeting. Four more meetings were proposed in second phase study.
- Get information from documents prepared by project team. Project documents will be prepared to distribute more information to wider stakeholders.
- and Comments on the document. Ask for comments from stakeholders.

10.2 Initial outline of major policy dialogue steps that are to be conducted through the two project phases.

The policy dialogue outline in the study for China could be given as following:
In the first phase period:

- Contact with possible stakeholders and inform them about the activities for this study.
- Project meeting including stakeholders. This happened in Sep.18 in Beijing. Officials from four departments in National Development and Reform Commission(NDRC), Ministry for Foreign Affairs, Ministry for Agriculture joined the meeting and gave their comments on the project and proposal for second phase study.
- For the phase one, report in Chinese will be Prepared to distribute to stakeholders and get feed back from them.
- Presentation for this study will be made in several domestic workshop and international workshops.

In the second phase study:

- More stakeholders will be invited. Based on the design for second phase study, much more large size of stakeholders will be involved in the process based on the stakeholder suggested in above session.
- Four workshops will be organized for this phase study. Participants will include people from central government, local government, research institutes, NGOs, companies.
- Both study summary and technical report will be prepared in Chinese for distribution.

10.3 Outline of background material to be prepared for policy dialogues.

Basically besides project document, specified document for stakeholder will be prepared. The content could be given as following:

- Project background
- Objectives
- National or local development goals and policies
- Sector development
- Contribution to climate change

- Future development path
- Analysis on the policies: synergy and difference
- Difficulties for implementation of policies
- Policy recommendations

10.4 Overview of available regional scenario's for country/region

10.4.1 Application of SRES on China

Application of SRES scenario to China was developed. By following SRES storylines, a set of story lines was formulated for China by defining several key driving factors such as GDP growth, population, energy efficiency improvement, etc. These story lines were developed based on the study output from several lectures. The future development patterns used were mainly taken from recent studies on the SRES emission scenarios.

First, in the scenario study for China, we defined several development patterns for China and the world by addressing key driving factors such as GDP growth, population, changes in economic structure, energy resource availability, technology improvement trends, etc. China's development patterns were emphasized in formulating the story lines. Various comments were collected from researchers engaged in related studies, particularly from researchers in China.

We defined four development paths for China and the world. They are briefly described as follows.

Catch-Up Scenario(Scenarios C): which basically comes from SRES A1 scenario. This scenario describes the case of rapid and successful economic development in China. Socioeconomic development follows the successful experience of OECD countries. Per capita GDP will reach the 1990 level of the OECD countries before 2050, and will almost catch up with that of the OECD countries by the end of the next century (it was 1/50 of the OECD level in 1990). The population growth path in China will follow the experience of the OECD countries, with the population reaching around 1.5 billion by 2040 and then decreasing to around 0.8 billion in 2100. The global economy is also set as a high-growth scenario. The primary drivers for economic growth and development are high human capital (education), innovation, technology diffusion, and free trade. Prosperity therefore becomes the key scenario driver. The scenario logic of successful development assumes smooth growth with no major political discontinuities or catastrophic events. Compared to the rapid economic growth, population growth remains at a low level as a result of high education, stable social relations, and incentives for innovation and experimentation. Developing countries will follow a similar transition to that of the OECD countries by the mid-21st century. Fertility rates in the scenario range from 1.3 to 1.7 children per woman. The global population grows to some 9 billion by 2050, and declines to 7 billion by 2100. The gaps between current developing and developed countries will close in a similar manner to the way in which the gaps between Japan on the one hand and Western Europe and the U.S. on the other closed in the 20th century.

The high economic growth will have pressure on energy supply. This scenario unfolds into several sub-scenarios as a function of different direction taken by technology change. The key question is which primary resources may become economically accessible in the future, and which technologies will become available to convert these primary resources into to the final goods and services demands by consumers. Four pathways are possible:

1) **C-B**: Balanced progress across all resources and technologies from energy supply to end use.
2) **C-C*:*** Clean coal technologies scenario (i.e., environmentally friendly except for GHG emissions and possible resource extraction impacts).
3) **C-G&O*:*** Oil/Gas scenario. Smooth transition from conventional to unconventional oil and gas, tapping the vast occurrence of unconventional fossil fuels, including methane cathrates.
4) **C-T*:*** Bio-nuclear scenario. Rapid technological progress in non-fossil supply and end-use technologies, such as solar, nuclear and hydrogen-fueled end-use devices, such as fuel cell.

Domestic Supply Scenario (Scenario D): which comes from SRES A2 scenario. The basic thrust of this story line is that economic development will mainly rely on domestic resources, in terms of both natural resources and technological resources. This means that the world consolidates into a series of roughly continental economic regions. Regions pursue different economic strategies based on the resources and options available to them. Low-income regions increase per capita incomes slowly, while high-income regions seek to increase the incomes of residents. Income inequality becomes more pronounced within low-income regions and widens between regions. Because of the limited trade between regions, technology diffusion becomes slow. Technological change is rapid in some regions and slow in others. China's per capita GDP will be 1/6 that of the OECD countries by the end of the next century. The population continues to grow, reaching 3 billion by 2100.

Short Cut Scenario (Scenario S): which is developed based on SRES B1 scenario. The central elements of this scenario include high levels of environmental consciousness, successful governance including major social innovations, and major reductions in income and social inequality. Environment issues are well recognized by the Chinese government, and the quality of the environment may improve before reaching the worst level during the OECD development period (hence the concept of a shortcut). This is also a high-growth scenario. Per capita GDP reaches the 1990 level of the OECD countries around 2060, and will be almost half that of the OECD countries by the end of the next century. Population growth is same as that in the C scenario. Technology development is maintained at a high level, and is implemented in a pollution prevention mode.

Regional Equity Scenario (Scenario E): comes from SRES B2 scenario. The basic consideration in this scenario for China is that economic development will utilize resources so as to maintain equity for the future, while maintaining balance among regions as well as between urban and rural areas. Such an approach will be introduced based on the recognition of environmental issues and sustainable development. This scenario can be described as regional stewardship from a global perspective, based on a natural evolution of the present institutional policies and structures. It is characterized by limited population growth, medium economic growth, inequality reduction, weak global governance but strong national and regional governance, a strong deurbanization trend, strong pursuit of environmental improvement, and encouragement of renewable energy use. It is a low per capita economic development scenario. The per capita GDP will be almost 1/5 that of the OECD countries by 2100, but the total GDP will be higher than that in scenario S because of the larger population.

There were another two studies focus on Chinese emission scenario by following SRES scenario. One is collaborated by Energy Research Institute(ERI) and National Institute for Public Environment and Health(RIVM) in the Netherlands (Detlef, etc, 2002). Two scenarios were developed based on SRES A1 scenario and B2 scenario by given name as A1-C and B2-C scenario. Another study focus on domestic alternative development path for energy and emission scenario by Energy Research Institute (Jiang, etc., 2002), six scenarios were simulated when global development path is taken from B2 scenario. Brief description of these six scenarios was given in table 12. Figure 13 and 14 presents the results of this study.

Table 12 Description of scenarios

Scenario	Code	Description
Traditional development scenario	S1	Future energy and environment development follows the experience of industraialized country during their initial stage of industrialization. Large space for energy intensive industry because of relying on row material production and low innovation of knowledge which makes slow technology progress and high energy demand.
Conventional scenario	S2	Economy development and energy industry follows the experience of China in last several decades. Industry will continue to keep dominant for next several decades. Energy supply mainly rely on domestic resource.
Energy policy intervention scenario	S3	Energy industry is promoted by government with planning, emphases on clean energy and improvement of energy efficiency. International energy market is regards as one of the important source for clean energy. Energy policies from government could be well implemented.
Environment driven scenario	S4	Base on the understanding on domestic environment problem, much more environment policies will be introduced beside existing energy and environment policies. Energy supply and use will satisfy the requirement of domestic environment. Clean energy and clean production is a mainstream of the society.
Tiger development	S5	A higher economic growth is assumed. Conventional development pattern is same as that in scenario S2, when higher technology progress is assumed because of financial ability for

scenario		technology R&D.
Gray development scenario	S6	A lower economic growth is assumed. Conventional development pattern is same as that in scenario S2, when lower technology progress is assumed because of financial ability for technology R&D.

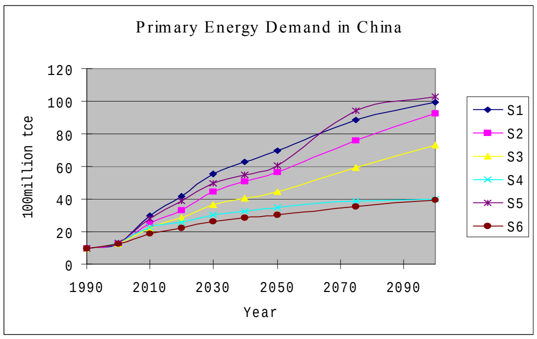

Figure 13 Primary energy use in China

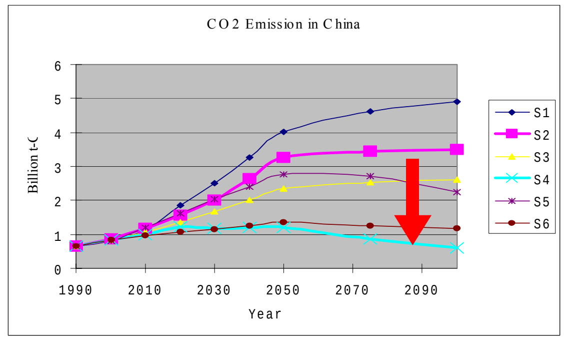

Figure 14 CO2 emission in China

Based on above studies for Chinese scenario, here we selected S2 scenario to be the baseline scenario and S3 to be sustainable development scenario.

In order to design the scenario, key driving forces used in the study include economic development (GDP growth), social efficiency change, technology progress etc. Here we will not discuss more about GDP growth change, just pickup two scenarios with very similar growth trend. Factors and relative policies considered in social efficiency change and technology progress is explained in table 13.

Table 13 Factors for key driving force

Driving forces	Sectors	Factors	Policies to promote the Change
Social Efficiency Change	Industry	Value added change within the sector Products structure change within one sector	Various policies relative to value added such as price policy, national plan for key industry, promote well working market Market oriented policies, national development policies.
	Residential and Commercial	Energy activity change within the sector	Public education, price policies
	Transport	Change of transport mode Traffic volume conservation	Transport development policies, public education

Technology progress		Efficiency progress for technology Technology mix change for one fuel Fuel mix change	Technology R&D promotion, market oriented policies, international collaboration Market oriented policies, environmental regulation National energy industry policies, import&export policies, tax system

10.4.2 Baseline scenario

We take conventional scenario to be the baseline scenario for China. In this scenario, basically reflect some planning and policies for energy and environment, but social transition to better consumption performance and technology progress follows historical trend. Energy efficiency improvement will slow down compared with last 20 years because of potential for conventional technology improvement is getting small. Basic assumption is giving in table 14.

Table 14 Assumption for baseline scenario

GDP	National planning before 2050, 7.5% from 2000 to 2010, 5.1% from 2010 to 2050. After that, 2.1% from 2050 to 2100
Population	National control plan, reach peak between 2040 to 2050 by around 1.6billion, then reduce to 1.5 by 2100
Per capita GDP	11 thousand US$ by 2050(1990 price), 26 thousand US$ by 2100
GDP mix	Rapid development of tertiary industry, slow change of production in second industry, material demand relied
Primary energy demand elasticity	0.5
Energy use technology progress	Fully diffusion of advanced energy use technology by 2050, technology efficiency is 20% higher than that in 2000, fuel cell vehical will be widely used by 2040
International trade	Generally improving of international trade, no trade bulwark
Annual average marginal cost improvement of energy exploitation technology	Coal: 0.7% Oil: 0.6% Natural gas: 0.3%
Non-Conventional energy use	No need
Modern renewable energy such as solar	Cost will be US$0.035/kWh by 2050
Nuclear technology progress	Capacity will be more than 90GW by 2050, cost to be US$0.045/kWh
Hydropower utilization	More than 910TWh by 2050
Modern biomass utilization technology	More than 70mtce biomass is available at cost lower than US$50/tce
Life style	Full useof clean energy, high ownership of electric

	appliance, commercial energy such as coal as major energy is widely use in rural area
Transport development	Rapid development, public transport oriented
Diet preference	Rapid increase of meat demand
Forest development	National plan, generally increase of forest by reforestation

Results for this scenario is given in table 15 and 16.

Table 15 Primary energy demand in baseline scenario

	2000	2010	2020	2030	2050	2075	2100
Coal	26.1	31.1	38.8	45.1	57.8	47.7	51.4
Oil	8.4	12.6	14.8	16.3	13.8	9.3	6.8
Natural Gas	1.1	3.0	5.8	10.7	22.1	29.8	32.2
Nuclear	0.1	0.2	0.6	1.2	4.1	6.1	9.3
Renewable	1.2	1.9	3.3	6.9	26.5	64.0	73.5
Total	36.9	48.8	63.3	80.2	124.3	156.9	173.2

Table 16 Emission from energy activities in baseline scenario

	2000	*2010*	*2020*	*2030*	*2050*	2075	2100
CO2	8.50	11.84	15.64	20.02	32.60	34.52	34.97
N2O	31.9	43.9	58.0	77.9	136.6	134.5	141.0
CH4	10.70	12.93	15.55	18.24	22.73	19.54	14.25

10.4.3 Sustainable Development Scenario

More strong policy intervention, technology progress and better consumption performance is given for this scenario to reach clearer future. Basic assumption is given in table 17.

Table 17 Basic assumption for SD scenario

GDP	National planning before 2050, 7.5% from 2000 to 2010, 5.1% from 2010 to 2050. After that, 2.1% from 2050 to 2100
Population	National control plan, reach peak between 2040 to 2050 by around 1.6billion, then reduce to 1.5 by 2100
Per capita GDP	11 thousand US$ by 2050(1990 price), 26 thousand US$ by 2100
GDP mix	Rapid development of tertiary industry
Primary energy demand elasticity	0.43
Energy use technology progress	Fully diffusion of advanced energy use technology by 2050, technology efficiency is 30% higher than that in 2000, fuel cell vehical will be widely used by 2030
International trade	Generally improving of international trade, no trade bulwark
Annual average marginal cost	Coal: 0.4%

improvement of energy exploitation technology	Oil: 0.8% Natural gas: 0.3%
Non-Conventional energy use	Non-Conventional gas is needed after 2040, small demand for non-conventional oil
Modern renewable energy such as solar	Cost will be US$0.04/kWh by 2050
Nuclear technology progress	Capacity will be more than 170GW by 2050, cost to be US$0.045/kWh
Hydropower utilization	More than 910TWh by 2050
Modern biomass utilization technology	More than 70mtce biomass is available at cost lower than US$50/tce
Life style	Full use of clean energy, high ownership of electric appliance, commercial energy is widely use in rural area
Transport development	Rapid development, public transport oriented
Diet preference	Rapid increase of meat demand
Forest development	National plan, generally increase of forest by reforestation

The results is briefly given in table 18 and 19.

Table 18 Primary energy demand in SD scenario

	2000	*2010*	*2020*	*2030*	*2050*	2075	2100
Coal	26.1	31.1	38.8	42.1	57.8	47.7	51.4
Oil	8.4	12.6	14.8	15.5	13.8	9.3	6.8
Gas	1.1	3.0	5.8	8.0	22.1	29.8	32.2
Nuclear	0.1	0.2	0.6	1.0	4.1	6.1	9.3
Renewables	1.2	1.9	3.3	5.1	26.5	64.0	73.5
Total	36.9	48.8	63.3	71.7	124.3	156.9	173.2

Table 19 GHG emission from energy activities

	2000	*2010*	*2020*	*2030*	*2050*	2075	2100
CO2	8.33	10.79	13.60	16.34	21.91	20.49	21.18
N2O	31.0	39.3	48.7	60.1	84.3	73.9	79.9
CH4	10.38	11.49	13.29	14.59	14.69	12.26	11.63

10.4.4 Option to reach SD scenario

By comparing the two scenarios, we provide following policy options to reach sustainable development scenario:

- Existing policies should be continued implemented such as energy efficiency planning, efficiency standard, promotion of renewable energy development etc..
- Focus on technologies progress. Technologies progress play key role in low energy demand future. In short-term, technology options identified in table ??? could contribute a lot for the SD scenario. And based on the experience from energy development in China, technology options are easier to be adopted

through market or government promotion. These options are normally no-regret options. Technology R&D should be further realized and make more effort. Some key technologies for future energy system in China should be invested more such as modern renewable technology(large capacity wind turbine and solar energy), clean coal technologies(IGCC, PFBC), fuel cell technologies etc. Technology localization is also an important factor for wide diffusion of advanced technologies.

- Extension of energy efficiency standard. Based on the existing energy standard system, more and more production should be included to reach energy efficiency standard.
- Use of energy tax. Energy tax could be introduced to promote further energy conservation and environment protection. Selected sectors could be applied such as transport, and area with heavy environment burden.
- Further development of renewable energy. Renewable energy technologies made significant progress recently especially for wind turbine. Policies to promote more renewable energy should be designed. More incentives should be given to power companies to utilize more renewable energy.
- For GHG emission reduction, non-CO2 emission reduction option should be realized which in many case are low cost and even no cost.

10.5 Overview of available tools for analysis of alternative development trajectories

For energy sector analysis, IPAC model will be applied which was briefly described in session 7.1. In IPAC model family, IPAC-AIM/Local model will be selected for Chongqing study; for longer term analysis, IPAC-emission model will be used.
For agriculture sector analysis, DSSAT model will be used. See session 7.2 for description.

11. Capacity building needs defined in relation to the project activities

Following needs were given based on the study and research for policy making process on climate change and domestic environment issues.

- Enhance the insights and experiences about methodological approaches, analytical tools, case studies, and participatory approaches
- Methodological project workshop to discuss common methodological issues and complexities raised in the country case studies
- Ways to link research and policy making process.
- Experience in developed countries for their improvement on environment issues.
- Collaboration of individual experts from the DC partners on cross-country issues and publication of the results in international journals

12. Work plan for Phase II proposal.

12.1 National Study

12.1.1. Issues to be addressed in the country study

- Further identification on current national policy trends and possible gaps to reach long term development objectives
- Case study for selected examples of development actions and policy frameworks that have led or will potentially lead to positive results for dealing with climate change

12.1.2. Specific subsectors to be focused

- *Energy Sector*

- Clean coal technology development in China. Major existing technology development and policy will be reviewed, specific policies to promote further clean coal development will be addressed.
- The introduction of renewables (wind, biomass and small hydro energy) in the energy system, and particularly to help achieving the goal of improving the access of rural population to modern energy; Strengthening of policies and measures to foster the use of renewables through financial mechanisms of the Climate Convention
- Energy efficiency measures in industry. Review the historical policy process, addressing policies packages for new administration framework which market will play more role for energy efficiency improvement.
- Urban transport system development. Exploring the synergy between reducing local air pollution and mitigating GHG emissions in the urban transportation sector through the design of policies and measures.

- *Agriculture sector/food security*

- Modify agricultural production structure and design agricultural system based on specific economic and natural conditions. Review successful cases on agriculture development in China, and classify suitable mode or approach for different agriculture regions.
- Strength technologies innovation and diffusion systems construction. Many researched have been supported by governments and organizations in China and some results have been successfully applied in practice such as variety improvement, water saving technologies, formula fertilization technologies etc. The research will give some brief introduction on some successful technologies related to sustainable development and food security.
- Increase ability to alleviate disaster influence on agriculture. Rising temperatures and acute water shortages make agricultural practice more difficult than before. Loss of agricultural land and lower crop yield as droughts and severe weather events decrease the amount of food production. Given adaptation options is necessary to decrease adverse impacts of climate on agriculture.

12.2 Regional study: Chongqing

12.2.1 Objectives of the Chongqing study

The Chongqing project has the following overall objective:

- To develop strategies and policies that meet development priorities of the Chongqing region and address climate change, focusing on energy and food/water security and to draw lessons for applying such a strategy in other parts of China.

The following key questions were identified on the basis of the above-mentioned development objectives and the results of phase I, looking at both sectors. Further specification of these questions will take place on the basis of detailed survey and stakeholder consultations in the region:

<u>For the energy sector:</u>

1. How to provide sufficient energy in the Chongqing rural areas to support the rapidly growing economy and living standards?
2. How to solve the problem of environmental impacts during energy sector development?
3. How to promote clean technology development to contribute to energy saving and local economic development?

<u>For the agricultural sector:</u>

1. How will the strengthening and restructuring of the agricultural sector (including water availability), aimed at an increase in agricultural production, be affected by climate change?
2. What scientific, technological and societal responses are required to deal with the impacts of climate change? What climate-friendly and climate-safe technologies could be implemented in this region?
3. What role do the food industry and markets have in the development of a climate friendly and climate-safe agricultural sector. How can recycling of waste and closing the nitrogen and carbon cycle between various sectors contribute to the sustainable development of the region?

On the basis of the results for the Chongqing region, the study also aims to draw lessons for other parts of China and contributing to the international discussion by:

- Identifying promising policy strategies for other regions within China for making transitions to long-term sustainable development patterns.
- Exploring what lessons can be drawn for international co-operation, specifically considering how incentives for regionally and nationally integrated development and climate strategies can be created at the international level.

12.2.2. Work plan for Chongqing study

The working plan follows the steps as defined in the diagram; all steps are carried out in close co-operation with national and local stakeholders. Steps 1, 2 and 3 have been partially completed for the Chongqing region and will be refined in phase II in close collaboration with regional research partners and stakeholders.

Steps and relevant activities in the working plan (every step concludes with a progress report).

Step	Activity
1.	Reviewing development strategies in the Chongqing region for the energy and agricultural sectors. Carried out mainly by project team members and local participants.
2.	Reviewing the development goals, constructing development scenarios.
3.	Further refining of the policy questions related to energy and food security. A workshop will be held in Chongqing to determine the questions on which the next steps of the project will focus.
4.	Identification and analysis by project team of the policy options for the questions identified that address both the development goals and climate. Prioritization in consultation with stakeholders. Analysis of the impact of climate change in the region based on the baseline development scenario. Evaluate findings of the first four steps, confirm findings and make adjustments where necessary.
5.	Use the DSSAT crop-growth model to explore agricultural production capacity under climate change scenarios. Use the IPAC model for the scenario runs and policy assessment in energy sector. Assess emissions related to the alternative development scenarios.
6.	Formulate possible policy strategies (towards sustainable development) and calculation and analysis of their consequences for the larger Chongqing region. Discussion of the results of analysis with local and regional policy makers. Exploration with main stakeholders of development strategies and policies that both meet development priorities of the region and address climate change, focusing on energy and agriculture.
7.	Up-scaling of regional results to national level for identification of promising policy options within China for making transitions towards long-term sustainable development patterns. Discussion of the results of the analysis with regional and national policy makers. Exploration of development strategies and policies with main stakeholders that both meet development priorities of China and address climate change, focusing on energy and agriculture. Explore what lessons can be drawn for international co-operation, specifically considering how incentives for integrated development and climate strategies can be created at the international level.

12.3 National Workshops

Energy and agriculture – Four workshops for involvement of stakeholders. Two at beginning of the second phase study at Beijing and Chongqing, two at final report period in Beijing and Chongqing.

12.4 Project team

Jiang Kejun – general coordination, technical coordination of energy case study
Ju Hui – technical coordination of agriculture/food security study
Zhou Dadi – energy policies, economic plans, climate change activities
Lin Erda – Agriculture policies, scenario and technology options
Hu Xiulian – energy policies, technology, and modeling
Su Zhengming – responsible for dialogue preparation
Zhu Songli – analytical tools (models, scenarios, indicators)

12.5 Cooperation with other Centers within the Project

CIRED – Energy (Policy/Regulation, Modeling, Scenarios) – participation in the Workshop
UCCEE – Energy (B-REED, SD indicators)
RIVM – Biomass, land-use change, scenarios
Canadian institutions (e.g. Agriculture Canada), through John Drexage – Zero tillage (carbon balances)
Tom Heller – biomass, land use change
Jan Verhagen – land use, agroforestry, reforestation in the Amazon region – participation of local team (working in Mato Grosso and Rondônia) in the Workshop

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[i] Measured in Purchasing Power Parity for the year 2000 in year 2000 dollars. See World Bank, *World Bank Indicators*, 2001.

[ii] Jeff Logan, Pacific Northwest National Laboratory, Washington, D.C., private communication, July 2002.