Atelier Climat et développement
coorganisé par l'Iddri et le Cired, Nogent-sur-Marne, 1er et 2 juillet 2002.

A clean future: sustainable development and climate change for China

Kejun Jiang
Center for Energy Environment and Climate Change
Energy Research Institute, China

Center for Energy Environment and Climate Change - Energy Research Institute - B-1407, Jia No.11, Muxidibeili, Xicheng District, Beijing 100038, China – Tel & Fax: 86-10-63908457 - Email: kjiang@eri.org.cn

Contents

A clean future: Sustainable development and climate change for China

Introduction

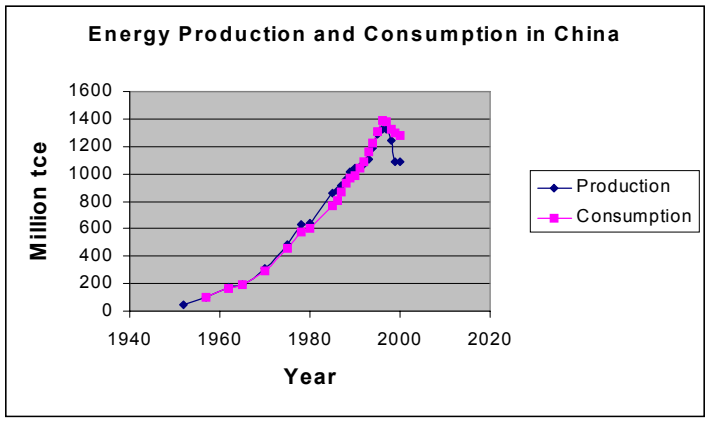
The 6th Conference of Parties of UNFCC made agreement on Kyoto Protocol in July, 2001. However because of the absence of the United States, the effect of the protocol is quite limited. The only way for developing countries to work on climate change described in the protocol by Clean Development Mechanism (CDM) is very weak now because the small demand for it.

Everyone have to start thinking about the future work what we can do for climate change. Uncertainties for key factor relative to effects of climate change still keep significant [IPCC TAR Synthesis Report], which is hard to answer major concerning from policy makers. Another way should be addressed, especially in developing countries.

Reducing GHG emissions covers very complex process, from social-economic development pattern to technology progress, and nature system. What happened in China for the last four years presents some interesting aspects.

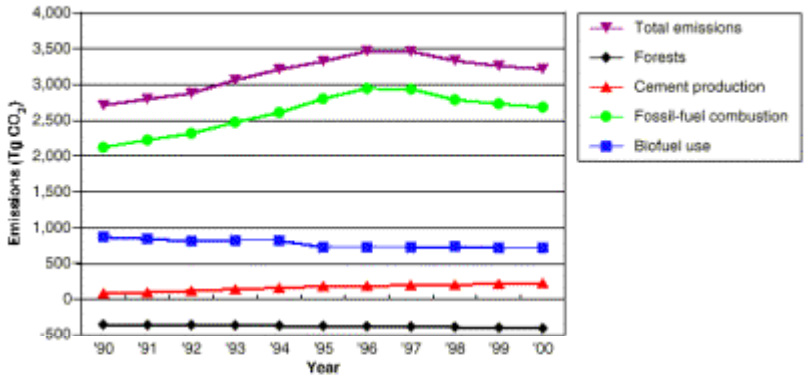
After 1996, energy production and consumption decreased (figure 1) [China Year Book 2000].

Figure 1. Energy production and consumption in China



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 there is a reduction on GHGs in China for last several years. However no climate change focused policies was 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 problems 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. The objective of this paper is to discuss the possible direction to contribute to climate change without mentioning much about climate change focused policies in China.

Sustainable development strategy in China

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 the 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 cannot 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 ensuring environmental protection. Controlling urban air pollution is a major aspect of this.

Review of contribution of policies on climate change

China is a developing country with per capita GDP was only $ 731 in 1997 [SDPC, 1998]. Developing the economy and improving the living standard as soon as possible are the long-term targets for China. China's per capita energy consumption was only 0.815 toe in 1997, being only equal to one sixth of the average of OECD. Industry and residential are the largest energy consumers. Energy consumption of construction and transportation is relatively lower. At present, rural areas are in short of commercial energy supply with low energy service level. Firewood and other primary biomass still dominated many rural areas. Therefore, the total energy consumption of China will continuously increase in a ling period in the future.

One of the basic principles of energy strategy is to supply enough energy for national economic development and to improve people's living

standard. To ensure energy supply is one of the tasks for China to integrate 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.

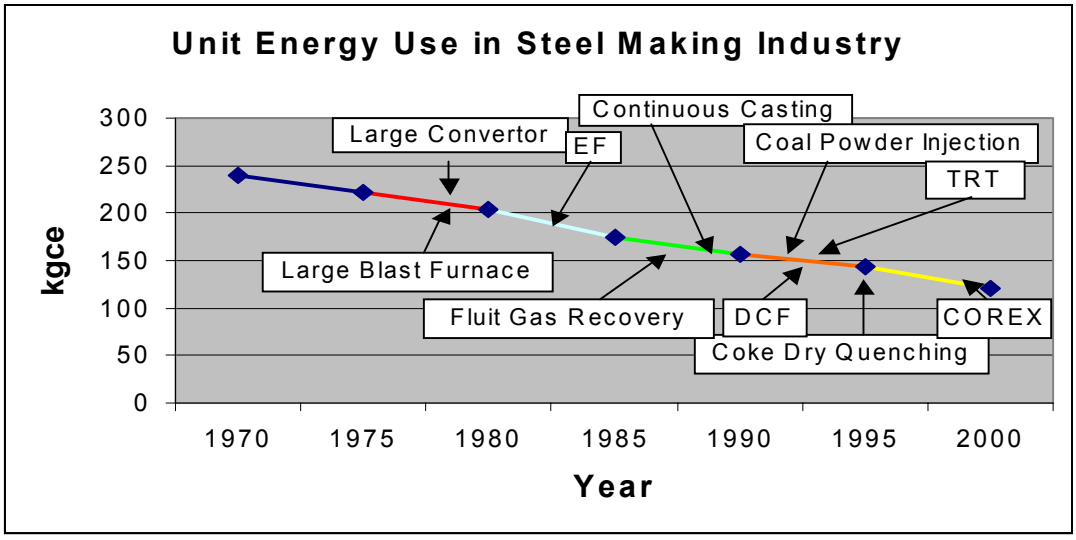
China has attached great importance to environmental protection, which has been taken as one of the basic national policies. China emphasizes on sustainable development and tries to avoid the "treating after polluting" path. China has taken part in and signed a series of international conventions concerning sustainable development and environmental protection.

Energy efficiency improvement and energy conservation are paid much attention in the sustainable 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 sustainable 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 play a very important role to reach low emission in China. Figure 3 shows an example in steel making industry for energy efficiency improvement and advanced technology diffusion.

Figure 3 .Technology progress and energy efficiency improvement in steel-making industry



Another major component of the sustainable energy development strategy is to improve energy mixture and gradually decrease the share of coal. China takes hydropower development as one of the important measures for improving energy mix and reducing fossil energy, especially coal. China has carried out a lot of projects with integrated benefits of irrigation and power. At the same time, China expedited the exploitation of natural gas and other clean energy. In recent years, the development of commercial renewable energy has also been paid much attention.

To ensure rural residents with better energy service and strengthen ecosystem and environmental protection in rural areas, China formulated and implemented concrete and effective planning for developing rural energy and new energy. This improved the utilization efficiencies of traditional energy and other renewable energy, enhanced the energy service and expanded the utilization of renewable energy in rural areas.

Since 1980, China has obtained great achievement in energy conservation, of which 26% was from technical advancement, being around 157 Mt. 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 41.42 Mtce.

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, the added energy supply capacity reached 9.09 Mtce in 1996 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 pays great attention to 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 were adopted by national and by collective forestry centers. During the recent years, annual added forestation arca 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 0.96 t from 1 $m^3$of living forest, total carbon dioxide absorption from forestry actions reached 2.414 billion tons during 1980-1996.

Energy and CO2 emission scenario for China with focus on domestic development

In order to explore the policies to reach low emission trajectory, a set of emission scenario for China was developed based on B2 scenario in SRES, without concern on climate change focused policies.

In the study IPAC-emission model was used. This model is revised from AIM-linkage model and constructed with focus on China. The components of the model framework were adopted from previous studies. The energy sector top-down module was developed based on the Edmonds-Reilly-Barns (ERB) model (Edmonds *et al.*, 1983; Edmonds *et al.*, 1995; Edmonds *et al.*, 1996), which is widely used for emission analysis; the end-use module was taken from the AIM/end-use model (AIM Project Team, 1996; Hibino *et al.*, 1996); and the land-use module was developed from the Global Trade Analysis Project (GTAP) model (Hertel, 1997). This new model structure maximizes the ability to simulate a variety of inputs at a variety of levels, incorporating the strengths of both top-down and bottom-up approaches. A bottom-up model reproduces highly detailed processes of technology development related to energy supply and demand, in order to determine future improvement of end-use efficiency. A top-down model, on the other hand, estimates equilibrium of energy supply and demand, and then determines energy prices that reflect not only energy service demand, but also energy efficiency improvement.

Similar with SRES scenario development, storylines of development were established. Then, future projections were made by the integrated assessment model for energy use, energy production, industrial processes, land-use changes, agricultural production, livestock, etc. from 1990 to 2100 according to the storylines. These projections were finally converted to the GHG emission scenarios. Table 1 gives the name for these scenarios.

Table 1. Scenario description for China

Scenario	Name	Description
Conventional development scenario	S1	Economic development and energy use follow the pattern of developed countries at their similar period, which high energy intensive industry dominant, slow technology progress, energy supply relying on domestic resource.
Keep the way development scenario	S2	Economic development and energy use keep similar way with last decades, industry keeps major sector of economy, energy supply relies on domestic resource, slow progress for clean energy.
Policy driven scenario	S3	Government makes policy to promote energy supply and consumption, makes plan for clean energy, clean technology R&D and diffusion, energy supply also from international market
Environment driven scenario	S4	Based on the understanding of domestic environment, with the government energy policy implementation, further environment policies will be introduced to go to a better environment friendly world by enhanced clean technology R&D and diffusion, regulation and international collaboration.
High growth scenario	S5	High GDP growth rate
Low growth scenario	S6	Low GDP growth rate.

Figure 7 to 14 present the results. What we emphasized is to find policy implementation to reach a clean development pattern, for example from S2 scenario to S4 scenario. Domestic economic development policies, energy policies, technology policies and environment policies are applied.

Figure 7. Primary energy use in China

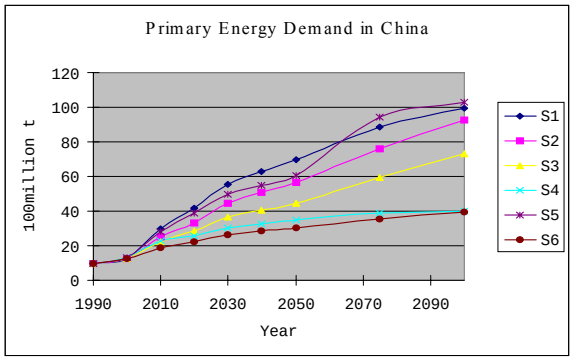


Figure 8. CO2 emission in China

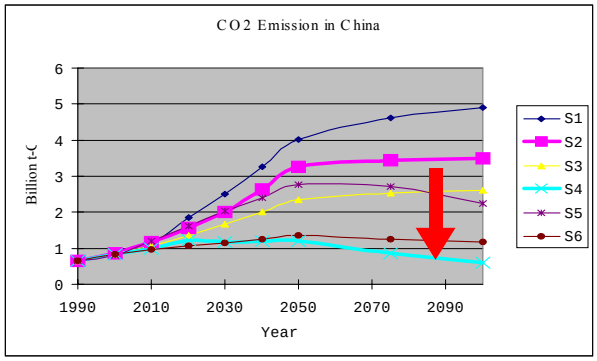


Figure 9. Primary energy mix

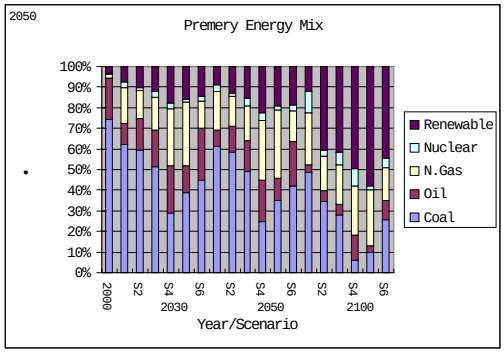


Figure 10. Final energy use by sector

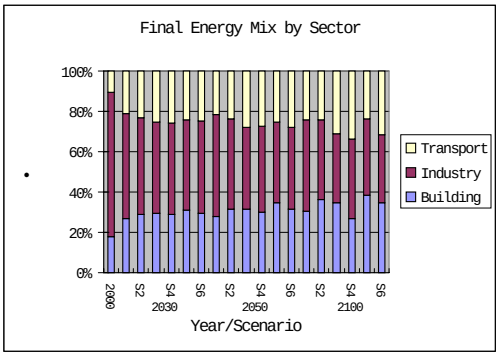


Figure 11. N2O emission

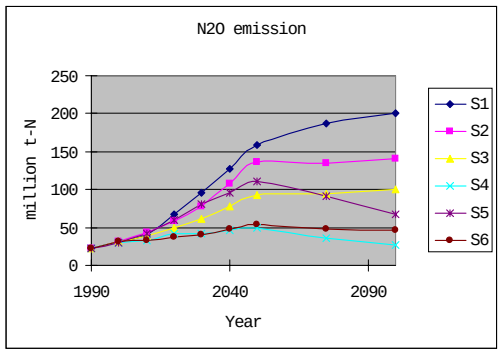


Figure 12. CH4 emission

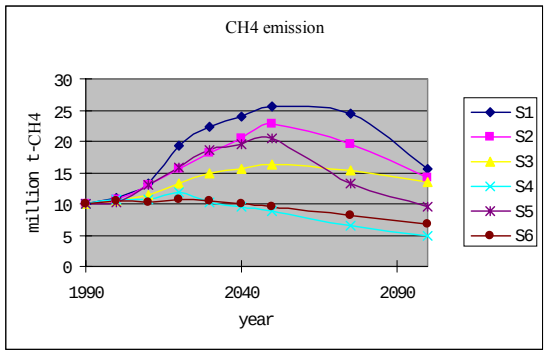


Figure 13. CO emission

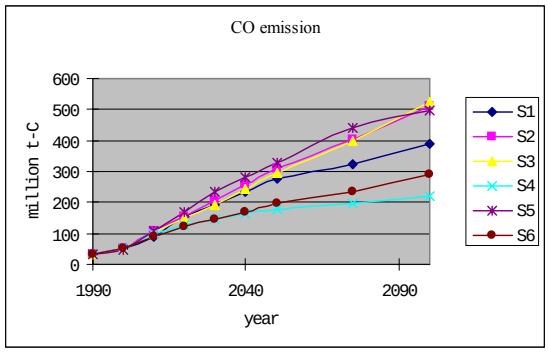
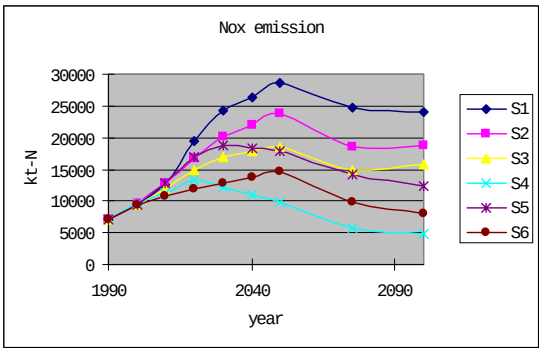


Figure 14. Nox emision



Analyzing on the policies among different scenarios, it is found the for the clean scenarios much of the enhanced policies are well match the policies under the sustainable development strategy. Especially in the early period, because of the lack of experience to combat with climate change, focusing on sustainable development is the major way for China to contribute to climate change mitigation.

Cost analysis for CO2 emission mitigation in China

In the scenario study for China, cost was simulated for CO2 emission mitigation with focus on scenario S2. Basic assumption for the simulation includes:

- Annex I countries will start to introduce climate policies from year 2000.
- China and other developing region will start from 2020.

S2 scenario is selected to be the baseline scenario. Carbon tax is introduced in the model simulation to analyze the indirect cost (GDP loss). Table 2 shows the various cost for different reduction rate compared with baseline scenario.

Table 2 Economy impact of CO2 mitigation

Year	Primary energy in baseline (EJ)	CO2 emission in baseline (mt-C)	Reduction rate (%)	GDP loss (%)
2010	53.78	1090	0	0
2030	96.83	2030.4	15.8	1.06
2050	165.9	3306	33.4	1.68
2100	271.65	3546	64.2	2.2

It is found from the cost analysis that larger emission reduction rate has larger GDP loss. Anticipated long-term response could have less impact on economy than short term action. There is also possibility to promote economy if some clean technology and other technologies could be the leader producer in the world.

Policy implementation framework

In order to avoid political barrier induced through international negotiation process for climate change, future thinking for GHG mitigation should be well combined with domestic sustainable development strategy,

with international collaboration. Several studies [Jiang *et al,* 1998, Hu *et al,* 1996] show that policy for climate change could be implemented in China in the following ways:

Combine policy with domestic sustainable development strategy

The environment problem is now well recognized in China. Sustainable development is an important factor in national development for both short- and long-term plans. Agenda 21 for China, announced by Chinese government in 1994, addresses the sustainable path in the future, which covers many energy activities. Policy options assessed in this study, such as clean energy utilisation, including natural gas, and nuclear and renewable energy, could well match the targets described in these national plans.

Develop no-regret opportunities

Much of the potential emission reductions discussed above could be achieved through market mechanisms (often even with finding benefits larger than costs). Many energy-saving oriented projects could contribute to CO2 emission reduction. Efficiency improvement discussed above could be well integrated with energy-saving strategies in China, as discussed in Chapter 3.

Integrate policies with the national energy development plan

Although energy market reform and regulation restructure is currently underway in China, energy supply will continue to be a key government concern. As shown in some scenarios, it is expected that future energy supply modes will slowly become cleaner, based on imports of natural gas and oil, implementation of clean coal technology and limited introduction of renewables. Such trends build on existing energy policies in China. Policies are formulated to increase both domestic production and imports of natural gas. Nuclear energy in China is currently in an expansion stage, in contrast with the situation in most Western countries, and our baseline scenarios indicate that the nuclear power capacity will continue to increase. Renewable energy development is also emphasised by government. In the past, large investments have been made into large hydropower projects. Modern renewable energy such as wind power and grid-connected solar energy has been prompted by China. The options discussed for mitigation policies could be seen as a stronger effort in these directions.

Use international mechanisms such as CDM, as defined in the Kyoto Protocol

These mechanisms focus on GHG emission reduction and domestic sustainable development and could help reducing some of the political and financial barriers to greenhouse gas mitigation in China. CDM could be a good pilot phase for future technology collaboration. It's important not only in itself; future trend of technology collaboration will be the focus. Because

US did not join Kyoto Protocol, other collaboration mechanism should be developed, US could not be out of the group.

Match domestic economic instruments

Tax reform in China started 10 years ago. So far there is no energy tax. However, energy subsidies have been reduced and a fuel tax for transport will be established soon. A carbon tax may not be possible in the short term, but could be implemented through a mixed energy tax. Such effects could be enhanced through double-dividends, as discussed in the IPCC Third Assessment Report (IPCC, 2001). In China, gasoline tax is undergoing to be started in the near future. Energy tax is also gone into mind of people. Even if it is complex to introduce strong instrument in China, experience from developed region could really help China's clean future.

Develop international collaboration on technology sharing

The study shows the clean technology plays key role to mitigate GHG emissions in the world. International collaboration will promote clean technology diffusion in China. Proposed collaboration on technology sharing including collaboration on new technology R&D which involve both institute from developed countries and developing countries, free or low cost transfer of key clean technologies to developing countries, especially in least developed region. Support local development in developing region is a key to further improve environment in developing countries. Technology transfer should not burden the economic development. Benefit from environment conservation in developing countries will have significant contribution to environment in developed countries. Public fund could play important role in clean technology sharing.

The key issue here is that climate change policies should be included in a national development strategy to create a more divergent development path for addressing clean energy activities. If climate change is well recognized in China, more investments and enhanced technology transfer for clean technologies should be required.

Technology strategy

Technology plays a key role in climate change mitigation as several studies [IPCC, 1996, 2001; Jiang *et al.*, 1998] show. 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 plays a 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 be

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 1) [Hu *et al.*, 1996, Jiang *et al.*, 1998]

Table 1. 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.

The long-term scenario study for China suggested following key technologies for the purpose of climate change [Nakicenovic, 2000, Jiang *et al.*, 1999]:

- Modern renewable energy production (solar energy etc.)
- Advanced nuclear power generation
- Fuel cell
- IGCC/Advanced clean coal technologies
- Advanced gas turbine
- Unconventional nature gas and crude oil production technologies
- Syn-fuel production technology

Basically, these technologies are also in the list for government to think about except unconventional energy technologies. Because of the 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 around 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 a large potential domestic market 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.

Other domestic policies

Outside technology development strategy, energy and environment related policies could be developed to cover the goal of climate change. Experience from other countries is also useful for development of relative policies. By thinking about the policy framework for economic development, energy and environment, following countermeasures could be considered:

Environment strategy covering climate change/ Pilot action.

Domestic environment issues are well recognized in some developed region in China. Many local governments published concrete policy frameworks. Review on these environment policies show there is almost no climate change issues included. Most of these environmental policies focus on short-term action to deal with various local environmental problems. Many local environmental problems could be improved within several years. Environment policies could get climate change issue as medium-term and long-term target. Pilot action should be encouraged for local government and capable enterprise for various purposes.

Developed region trade system

Some countries started to introduce domestic trading system. This also could be a possible way to be covered in countermeasure adopted in China. GEF is working in China on renewable energy portfolio system. Experience from this regime and other countries could be very good basis for possible trading system on CO_2 emission although it does not have short-term prospective.

Energy tax system

Energy tax system is commonly used in OECD countries. China is preparing to introduce energy tax system. Tax will be levied on vehicle fuel soon in China to replace road construction fee. This is a trend for future energy price system reforming. Many experts in China think that a carbon tax is still very far, but it is useful to think about a mixed tax system to include climate change issue.

Barriers for the environmental policy implementation

Sustainable development has been already setup as a government long-term target. Various efforts were made to promote economic development when environment was concerned. There is significant progress for air pollution control like SO_2 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 regulate pollutant emissions. Some of them work well but some take an other direction. Following barriers are recognized to be the reasons of the policies:

- High cost to implement the regulation. There is 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. Sometimes the policies could not reach the target because of the local conditions.
- Availability of clean technologies. In many cases, advanced clean technologies exist but with high fixed cost, it is hard for Chinese users to adopt them.

Conclusion

From the study, we can conclude as following:

- As an economy rapid growth country, future energy use and GHG emission will increase quickly. It is possible for China to be the largest country for CO2 emission after 2030 and per capita emission will be near to world average.
- There is potential for China to mitigate GHG emissions by various climate change policies and sustainable development policies.
- The technology progress plays very important role in GHGs emission reduction and energy use in China, which will significantly contribute to global and local environmental conservation
- The market mechanism is an efficient way for advanced technology diffusion in China
- International collaboration on knowledge transfer is a key factor to enhance the technology progress in China
- New environment policies are necessary to be designed at an early stage in China to integrate strategies for both local and global environment
- International collaboration on technology should be promoted rapidly to help China and other developing countries to enhance the ability for clean environment.

References

Bruce J., Lee H., Haites E. (eds). 1996. Climate change 1995-Economic and social dimensions of climate change, WGIII of IPCC. Cambridge University Press, UK.

Hu, X., K. Jiang, J.Liu. 1996. Application of AIM/emission model in P.R. China and preliminary analysis on simulated results. AIM interim paper. IP-96-02, Tsukuba, Japan.

Bruce, J.P., H. Lee & E. Haites (eds). 1996. Climate change 1995- Economic and social dimensions of climate change, IPCC. Cambridge University Press, Cambridge.

Streets, D., K. Jiang, X. Hu, J. Sinton, X. Zhang, D. Xu, M. Jacobson, J. Hansen. 2001. Recent reductions in China's emissions of carbon dioxide, methane and other greenhouse gases. To be published.

IPCC. 2001. Climatre change 2001: mitigtion. Working group III, Cambridge University Press, Cambridge.

IPCC. 2002. Synthisize report of TAR. To be published

Jiang, K., X. Hu, Y. Matsuoka, T. Morita. 1998. Energy technology changes and CO2 emission scenarios in China. Environment Economics and Policy Studies 1:141-160.

Jiang, K., T. Masui, T. Morita & Y. Matsuoka. 2000. Long-term GHG emission scenarios of Asia-Pacific and the World. Techological Forecasting & Social Change 61(2-3).

Jiang, K, T. Morita, T. Masui& Y. Matsuoka. 2000. Global long-term GHG mitigation - Emission scenarios based on AIM. Environment Economics and Policy Studies Vol.3, 2000.

Jiang,K., T. Morita, T. Masui & Y. Matsuoka. 1999. Long-term emission scenarios for China. Environment Economics and Policy Studies Vol.2:267-287, 1999.

Nakicenovic *et al.* 2001. IPCC Special report on emission scenario. Cambridge University Press, UK.

SDPC (State Development Planning Commission). 1998. Greenhouse gas mitigation from sustainable energy and forestry action in China, SDPC.