Carbon Intensity Trend and Policy implementation for Climate Change in China

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1. Introduction

6th Conference of Parties of UNFCC made agreement on Kyoto Protocol in July, 2001. However because of the absence of 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 think 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 emission cover very complex process, from social-economic development pattern to technology progress, and nature system. What happened in China for last four years presents some aspects interesting.

After 1996, energy production and consumption decreased (see 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 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. Objective of this paper is to discuss the possible direction to contribute to climate change without mention much about climate change focused policies in China.

2. 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 concerning 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.

scenario	name	description
Conventional	S1	Economic development and energy use follow the pattern
development		of developed countries at their similar period, which high
scenario		energy intensive industry dominant, slow technology
		progress, energy supply rely on domestic resource.
Keep the way	S2	Economic development and energy use keep similar way
development		with last decades, industry keep major sector of economy,
scenario		energy supply rely on domestic resource, slow progress for
		clean energy.
Policy driven	S 3	Government make policy to promote energy supply and
scenario		consumption, make plan for clean energy, clean
		technology R&D and diffusion, energy supply also from
		international market
Environment	S4	Based on the understanding of domestic environment, with
driven		the government energy policy implementation, further
scenario		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	S5	High GDP growth rate
scenario		
Low growth	S6	Low GDP growth rate.
scenario		

Table 1 Scenario description for China

Figure 3 to 10 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 5 Primary energy mix



Figure 7 N2O Emission



Figure 4 CO2 emission in China



Figure 6 final energy use by sector



Figure 8 CH4 emission



Figure 9 CO Emission

Figure 10 Nox Emision

By analysis 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 at the early period, because of lack of experience to combat with climate change, focusing on sustainable development is the major way for China to contribute to climate change mitigation.

3. Carbon intensity in China

Because of the progress on energy efficiency and diffusion of clean energy, carbon intensity decreased a lot during last decades. Figure gives the carbon intensity change from 1990 to 2000. Compared with 1990, carbon intensity in 2000 decreased 54%, with annual decrease rate 7.4% (see figure 11).



Figure 11 Carbon intensity change in China

Major contribution of carbon intensity decrease mainly came from high GDP growth and lower energy consumption growth. For last more than 20 years, energy elasticity goes low as 0.5 which is a key indicator for decrease of carbon intensity. Because of increase

of clean energy such as natural gas and hydro power is extending their share in total energy mix, carbon energy intensity also goes down, especially in recent years.

In the scenario study, the results show the trend of decrease of carbon intensity will continue with a slow down step(see figure 13). Carbon intensity in 2030 could be low as 23% to 46% of that in 2000, 17% to 35% for 2050. The annual decrease rate is between 2.5% to 4.8% from 2000 to 2030, 2.1% to 4.5% from 2000 to 2050. However for low emission scenario, much more stronger domestic policies and international collaboration is required. Other scenario study show also similar trend with diverged level of carbon intensity(see figure 14). But carbon energy intensity could go to different direction(see figure 15).



Figure 12 Carbon energy intensity change in China(emission from fossil fuel)



Figure 13 Carbon intensity trend in China from the scenario study



Figure 14 Carbon intensity trend in China from selected scenarios



Figure 15 Carbon energy intensity in China from selected scenarios

4. 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 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 future, which cover 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.
- *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).
- *Develop international collaboration on technology sharing*. The study shows the clean technology play key role to mitigate GHG emissions in the world. International collaboration will promote clean technology diffusion in China.

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.

5. Technology strategy

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 is 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 1)[Hu et al, 1996, Jiang et al, 1998]

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	High Efficiency Boiler, FCB Technology, High Efficiency
Technology	Electric Motor
	Speed Adjustable Motor, Centrifugal Electric Fun, Energy
	Saving Lighting

Table 1 Technologies contributing to GHG emission reduction in short and medium-term

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 at 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 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.

6. 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 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. Concrete policy frameworks were published by many local government. Review on these environment policies show there is almost no climate change issues included. Most of these environment policies focus on short-term action to deal with various local environment problem. Many local environment problem could be improved within several years. Environment policies could get climate change issue in as medium-term and long-term target. Pilot action should be encouraged for local government and capable enterprise for various purpose.

- 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 regiem and other countries could be very good basis for possible trading system on CO2 emission although it does not have short-term prospective.

- Energy tax system.

This is commonly used in OECD countries and 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 carbon tax is still very far distance, but it is useful to think about a mixed tax system to include climate change issue.

7. Barriers for the environmental policy implementation

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:

- 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.

8. Conclusion

From the study, we can conclude as following:

- 1) As a 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.
- 2) There is potential for China to mitigate GHG emissions by various climate change policies and sustainable development policies.
- 3) There is a significant descrease in carbon intensity from 1990 to 2000. Scenario study shows this trend could be continued for next several decades. Carbon intensity in 2030 could be low as 23% to 46% of that in 2000, 17% to 35% for 2050.
- 4) 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
- 5) The market mechanism is an efficient way for advanced technology diffusion in China
- 6) International collaboration on knowledge transfer is a key factor to enhance the technology progress in China
- 7) New environment policies are necessary to be designed at early stage in China to integrate strategies for both local environment and global environment
- 8) International collaboration on technology should be promoted at early time to help China and other developing countries to enhance the ability for clean environment.

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