

Toward a Low Carbon Economy: China and the World

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Toward a Low Carbon Economy: China and the World

Executive Summary

There is overwhelming documentation on the scientific, economic and social aspects of global climate change, and public concerns about its negative impacts have risen dramatically recently. There is no time for an impasse where at each country waits for others to take action first. After decades of climate negotiations, it suggest that the key is to break the current deadlock between the North and the South, and provide a fair and cost-effective post-2012 climate agreement architecture for both to unite together when facing the climate crisis. The global transition to a low-carbon economy, however, is a vast undertaking goal that also requires multilateral research cooperation between nations. For this purpose, this study aims to provide a systematic economic analysis of climate change economics and policy implications from the Chinese perspective, as well as the international collaboration research on the linkage between China and the world in pursuit of a global low-carbon world.

First in part I, we propose a fair emission burden or effort sharing framework based on accumulated consumption-based GHG emissions by modifying the current Greenhouse Development Rights (GDRs) framework, which was first proposed by Baer, Athanasiou and Kartha (2007) in UNFCCC Cop 13 at Bali. Though much analyses has been conducted to emphasize the imbalance between the production and consumption on GHG emissions, most of these previous studies only focused on international trade, but such analyses may lure attention toward trade protectionism, violating free trade principles. Our study, instead provide a new economic modeling of thinking the relationship between consumption, investment and GHG emissions. Then we modified the Greenhouse Development Rights (GDRs) framework based on the historically cumulative consumption-based GHG emissions for 1850-2005. Due to the data limitation before 1950, we assume at that time each country has limited trade thus consumption emissions are equal to the domestic emissions. Our study suggests that, the United States and EU27 together need to contribute over 2/3 of obligations, while China needs to contribute 1.6% and India is waved from the obligations for the time-being. Overall, high income countries need to share 86.3% of global responsibilities, upper and lower middle income countries share 8% and 5.6% respectively, and low income country only needs to contribute 0.1%.

Based on this modified GDRs results, we also propose a gradually step-in framework and a “Climate Treaty” regime for post-2012 international climate agreement architecture. Considering the current adrift climate negotiation, GDRs principle maybe not a protocol to be adopted in the near future, but it provides a basis to put forward a blueprint toward a global deal in terms of international financial flow and

technology transfer. To break the current climate negotiation deadlock and pursue a pathway to stabilize future climate, a consensus on graduation threshold according to the “common but differentiated efforts” principle, might be a realistic political regime by all the countries. Only the countries above the graduation threshold need to commit binding targets, while all the countries can participate in the “inter-country joint mitigation plan,” no matter they are voluntary or mandatory. The developed countries should commit to provide financial assistance and technology transfer, with these condition satisfied the developing countries can approach their graduation threshold sooner.

In part II, we analyze China’s own mitigation strategies, policies and institutions to participate in the global GHG emission reduction activities. First, we analyze the contribution of energy intensity reduction and energy structure optimization policies to decrease carbon dioxide emissions per unit of GDP, and analyze the effects of GHG emission reduction under two “no-regrets” climate scenarios. In addition, we analyze the effects of carbon emission reductions under various voluntary regimes, and discuss the future policy obstacles on technology transfer, market failure, financial liquidity, and so forth.

Then we focus on the policy design regarding appropriate choice of instruments in the context of Chinese economy. Our analysis suggests that in the short run the carbon tax should be the preferred instrument rather than cap and trade system, the latter would need a long-term learning and doing process for China. Furthermore, using a dynamic recursive computable general equilibrium analysis of Chinese economy, we also examine the effect of carbon tax on China’s on both economic and environmental system. Our study suggest that, although there is a small negative impact on the consumption in the short run, the environmental tax is less distorted than the capital income tax, value-added tax and other taxes in the second-best setting, thus a revenue-neutral carbon tax can achieve significant reduction on carbon emissions, TSP, SO₂ emissions, with ignorable impacts on GDP and consumer utilities. In addition, if we take into account the co-benefits from reducing TSP and SO₂ emissions, the health damages will be reduced at about 8-16% at the tax rate 10\$/tC; and 25-38% at the tax rate 20\$/tC in 2030. Finally, we also examine the distribution effects of carbon tax on different sectors.

Finally, in part III we demonstrate how the international cooperation can benefit China’s national climate change strategy in which the sustainable development targets are in the center. First, we give a thorough analysis of the ex-post experiences and lessons from the current Clean Development Mechanism (CDM) practices in China. We discuss three practical issues which are likely to jeopardize the cost-effectiveness of CDM projects in China: financial additionality, technology additionality, and emission reduction additionality. Then based on the case study of CDM practice, we further analyze the costs of “non-cap”, and costs resulted from recognizing no voluntary national “cap”. Finally, in order to overcome the drawbacks with the current

mitigation mechanisms, we propose a new mechanism for effective international cooperation – “inter-country joint mitigation plan” (ICP), which incorporates technology transfer, financial flow and emission reduction and prioritize local sustainable development under the principles of UNFCCC. Thus our new proposal conserves the merits of the current CDM practices but extended at a much larger scale.

In sum, ICP is a comprehensive voluntary emission reduction plan for attracting developing countries to participate in emission reduction actions, and encourage developed countries to contribute financial flow and technology transfer to developing countries, and unit both the North and South to achieve the global mitigation targets at a lower cost. Finally, under the ICP framework, we discussed how public-private partnership (PPP) principles can be implemented in practice, as well as the allocation of financial obligations based on the modified GDRs framework. Our study suggests that China should invest \$7 billion US dollars annually in emission reduction, so as to share a fair obligation to meet the stabilization level of 2 degree Celsius target, and the global annual mitigation costs are about \$439 billion (2005 price, USD).

To sum up, we propose a Modified GDRs framework for a fair and effective burden or effort sharing framework for countries to seek a convergence path toward a global low carbon economy for both developed and developing countries. Then we analyze the mitigation strategies, policies and institutions from the China perspective, and examine the potential effects of future carbon tax on both economy and environment. Finally we propose an ICP framework for the North and the South to unite together to combat for future global climate change.

0. Introduction: Global Climate Change and Challenges

0.1 Global Climate Change and Expected Impacts

There is overwhelming documentation on the scientific aspects of global climate change. While debate on whether or not the globe is indeed warming still ensues, and while there is still much we don't know, there are several important facts salient to initiating sound global policy concerning this matter. According to the IPCC fourth Assessment Report¹, the following facts can be observed (figure 1):

- 1) There has been unequivocal warming of the climate system. In the last 100 years, global surface temperature increased by 0.74 degree Celsius in the Fourth Assessment Report (TAR, AR4), which is higher than the corresponding trend of 0.6 (1906-2000) given in the third Assessment Report (TAR, AR3).
- 2) The global average sea level has risen at an average rate of 1.8 mm/yr since 1961 and 3.1 mm/yr since 1993 due to contributions from thermal expansion, melting glaciers, ice caps, and polar ice sheets.
- 3) The average annual extent of Arctic Sea ice has shrunk by 2.7% per decade since 1978 according to satellite data, while both mountain glaciers and snow cover have declined in both hemispheres.
- 4) Globally, from 1900 to 2005, heavy precipitation and droughts have been higher in frequency. Further, an increasing trend of intense tropical cyclone activity can be observed over this period.

In sum, the IPCC AR4 lends itself to illustrating that many natural systems and ecological processes are being affected by regional climate change, particularly temperature increases. Cline (2007) also suggests that, "the global aggregate effects from climate change will be negative, and that developing countries will suffer first and worst." The results are particularly important for the cases of China and India. Though the central estimates in the Cline study suggest that China may be a modest gainer in agricultural output under a business-as-usual scenario with carbon fertilization, the estimates ultimately turn to a loss (7% reduction in agricultural capacity) caused by either an offset from excluded damages or carbon fertilization effects that may not materialize in practice. There is no ambiguity in India's case. The prospects for Indian losses are substantial at 30-40%².

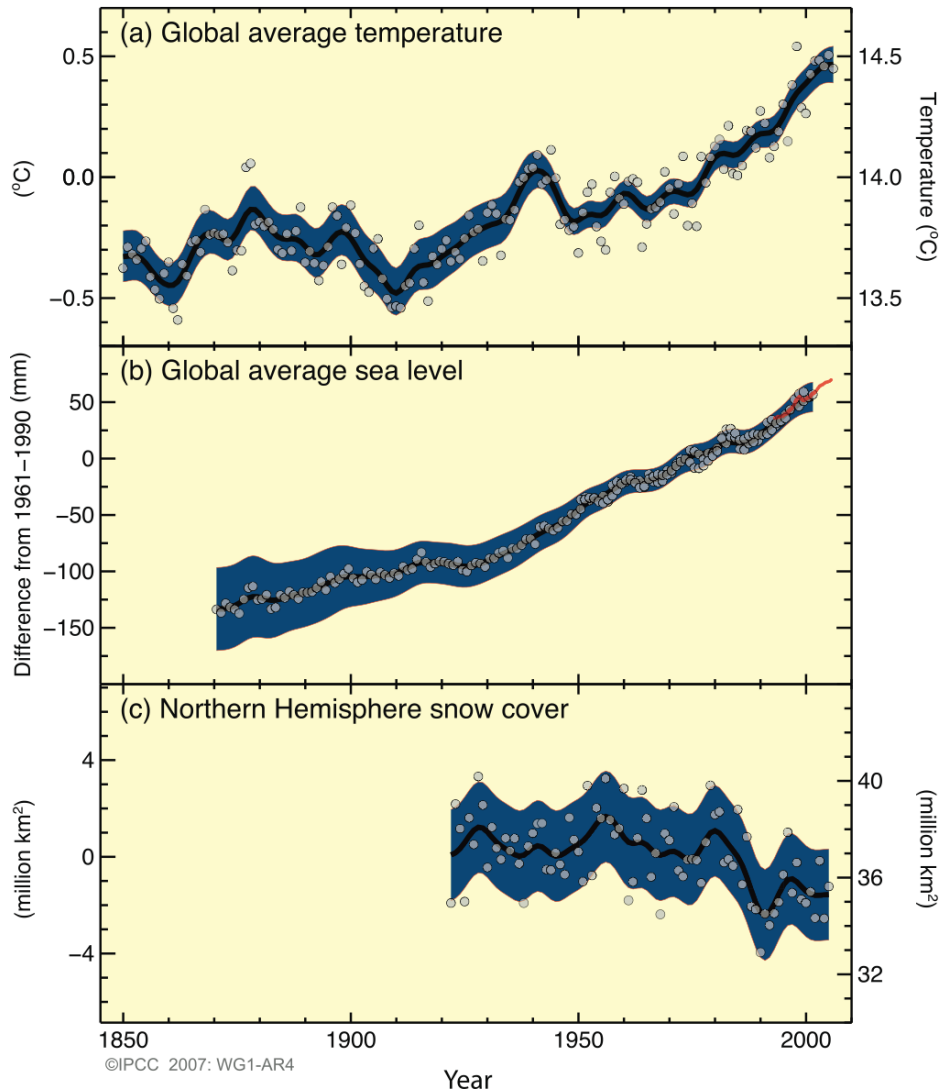
Based on recent study of impacts of climate change on Chinese agriculture conducted by Chinese Academy of Agriculture Sciences and AEA Group in UK, the future climate change will lead to significant decreases in total agriculture production by the

¹ Cited from IPCC AR4 "Summary for Policymakers of the Synthesis Report of the IPCC Fourth Assessment Report", IPCC, 2007

² Cline (2007), pp. 97.

2040s (-18% at IPCC A2 scenario, and -9% at IPCC B2 scenario³).

Figure 1. Changes in Global Average Temperature, Sea Level and Northern Hemisphere Snow Cover



The consequences of a rising sea level are also alarming. According to the IPCC AR4 WG2 Report, the current rate of sea-level increase for Asia is reported to be between 1 to 3mm/yr which is larger than the global average. Comparing the rate of sea level increase in the last decade and that in the whole 20th century, one can also see that the rate of sea level increase has accelerated relative to the long-term average (Arendt et al., 2002; Rignot et al., 2003). Besides, observed changes in extreme climatic events and severe climate anomalies have been observed in many Asian countries, including China. For example, the increasing frequency of extreme rains in western and southern China, floods in the Changjiang River area(s), and decreasing precipitation in northern regions. Additionally, increases in the areas affected by

³ IPCC A2 scenario: medium-high emissions from a continuously increasing global population; IPCC B2 scenario: medium-low emissions and lower population growth.

droughts have exceeded 6.7 *Mha* since 2000 in Beijing, Hebei, Shanxi, Inner Mongolia and North China, which exacerbates dust-storm frequency and aftereffects. Both the number and intensity of strong cyclones has also increased since the 1950s (Zhai et al., 1999; Ding and Pan, 2002; Zhai and Pan, 2003; Zhai, 2004; Chen et al., 2001; Yoshino, 2000, 2002; Zhou 2003; Fan and Li, 2005).

The Stern Review (Stern 2006) suggests to taking immediate action towards curtailing global climate change, and estimated that to stabilize GHG concentrations at around 550 ppm CO₂ eq. would only require 1-2% of global GDP, thereby avoiding damages that could be as high as 5-20% of global GDP. Both Nordhaus (2007) and Weitzman (2007) criticized the Stern Review for adopting an extremely low discounting rate that does not reflect current returns to capital, as well as the uncertainty and unknown parameters in the risk of distributions. Sterner and Persson (2007) pointed out that it ignores the relative price changes due to increasing scarcity, so that the effect of the discounting is counteracted. In response to these critiques, Dietz and Stern (2008) argue that the analysis should refer to the long-run risk free rates, and suggest the whole study is a combination of risk and ethics, rather than a positive study.

0.2 Global Challenges toward a Low Carbon Economy

The global transition to a low-carbon economy is a vast undertaking that will require unprecedented cooperation between nations. There is no time for an impasse where at each country waits for others to take action first. After decades of climate negotiations, it suggest that the key is to break the current deadlock between the North and the South, unite together to combat climate change. In addition, many co-benefit studies suggest that, the existing “no-regrets” mitigation options can induce more developing countries to contribute their efforts, taking moderate emission reduction target. However, many of these mitigation options require both financial and technology flows form developed countries, thus these voluntary efforts or taking moderate or binding targets from the South, should be built upon trust and cooperative spirit between the North and the South. To reach the ambitious goal of stabilizing future climate change under 2 degree Celsius, developed countries are also required to deepen their obligations.

In this study, considering the global challenges toward a future low carbon economy, *this* research considers both actions that China can take unilaterally, for example domestic energy saving targets and environmental protection, as well as global climate activities that China can take to engage internationally.

0.3 Research Objectives and Scope

This project aims to provide coherent and concrete economic policy that will help enable real action that put in motion a transition in China towards a low-carbon

economy. Such will require a comprehensive and overarching program encompassing all sectors of the economy, and engaging closely with international partners. Therefore, the project will address the major concerns and requirements regarding the implementation of such policy change from the perspective of developing countries, of which China is one special case.

This study will not overly concern itself with the debate as to whether or not the globe is in fact warming, or if carbon emissions cause climate change. The main assumption is that carbon emission is a “public bad.” Given the ubiquity of previous and directly related studies, this study does not conduct primary research on how important it is to avoid climate change by lowering carbon emission levels.

From an economic approach, the research will not discuss climate change from the perspectives of global morality, but rather focus on economic analysis—costs and benefits as well as their socio-economic implications for China.

At this stage, the scope of research is limited to carbon mitigation only, leaving open the possibility for adaptation or the addition of other environmental issues for subsequent study.

Part I. Fair Emissions: Modified Greenhouse Development

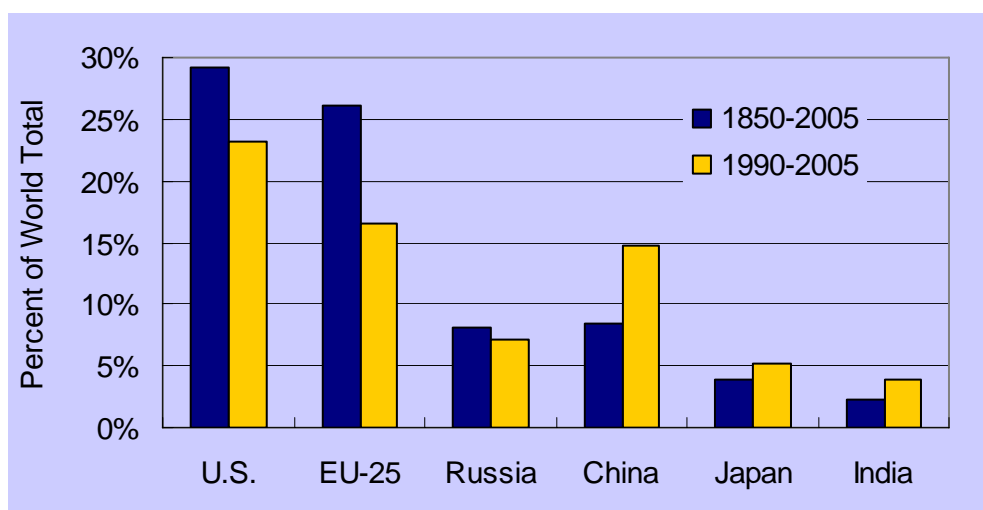
Rights (GDRs) and Mitigation Targets

1. History, Reality, and Future Trends

Climate change results from the accumulation of historical GHG emissions. Therefore, the accumulative amount of GHG historical emissions is one of the main tools for determining the climate change responsibilities of each country. Nowadays, the major cause of global warming is the large number of GHG emissions coming from the large-scale use of fossil fuels by developed countries through their industrial activities since pre-industrial era.

Based on the historical accumulative emission data from Climate Analysis Indicators Tool (CAIT) version 5.0 for the period of 1850-2004, we can see that the Annex I countries account for 75% of the world's greenhouse gas emissions, in which the U.S. and Europe (25) account for 29.4% and 26.4%, respectively. China alone counts for 8.1%, however, China's per capita carbon emissions are ranked 92nd, about the world average of 5 tCO₂ eq. per capita. Though developing countries emit less accumulative historical GHG emissions, if developing countries follow the same energy consumption pattern as developed countries, in the future developing countries might even exceed developed countries'.

Figure 2. Accumulative Historical Carbon Emissions in Different Time-Span



Source: Climate Analysis Indicators Tool (CAIT) Version 5.0. (Washington, DC: World Resources Institute, 2008) and statistic of Energy information Administration. Note 1850-2004 data is from CAIT and 2005 data is from EIA

If we only count historical carbon emissions from 1990 rather than from 1850, the share of developing countries is higher. For example, China and India's burden is almost doubled, while the shares of developed countries decline from about 76% to 61%. Thus, the starting point used when counting historical emissions is a major factor affecting the how large a burden each country should take when combating the global climate change crisis. A fair burden sharing rule should go back to the time when the industrial revolution started, when greenhouse gases began to accumulate and affect the global climate system.

The core issue for the future international climate system is how to restrict GHG emissions. In the future, different countries and regions might differ greatly from each other in GHG emission trends for differential policies and actions. Regarding industrialized countries, the future emissions of the European Union are flattening while the emissions of the United States have been continually increasing. From 2005 to 2030, the global GHG emissions from fossil fuel combustion will increase by 114%, while the proportion in global GHG emissions will increase from 40% to 55%. At that point, China and India will both have increased emissions and faster growth rates.

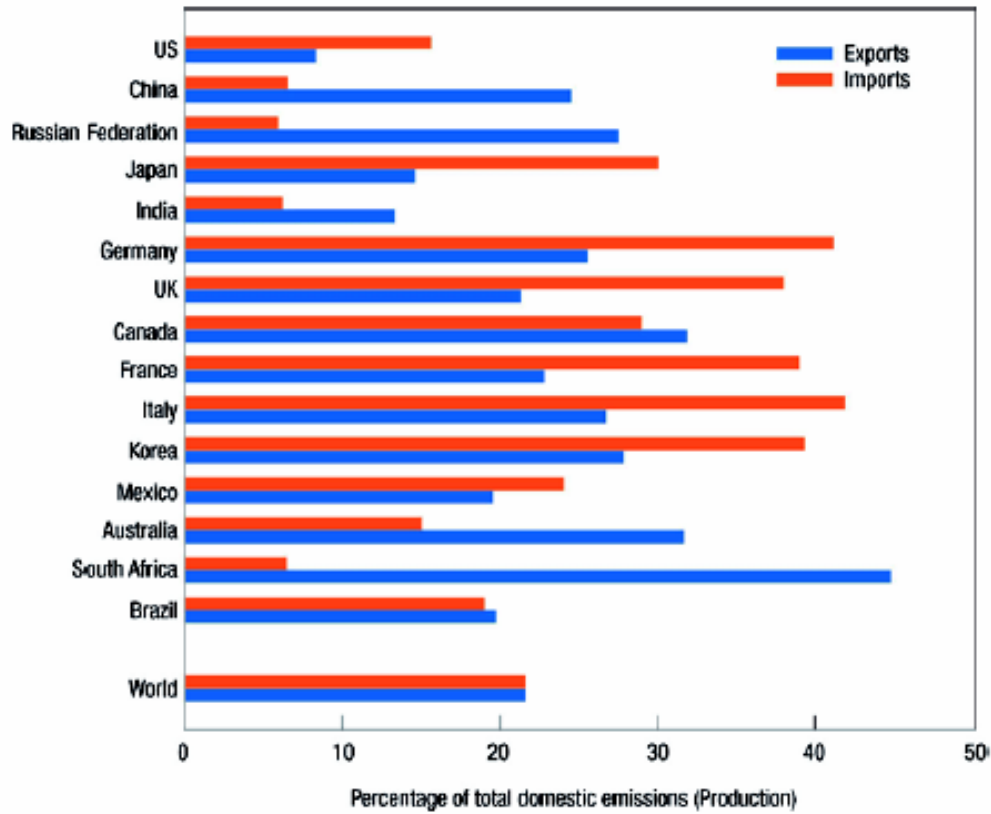
2. Consumption and Emissions

Different from the previous studies, in this project we emphasize the link between the consumption and the GHG emissions, and propose a new accounting system for calculating consumption-based emissions.

What are the relationships between consumption and greenhouse gases? Why should we pay attention to them? Based on economic theory, the ultimate goal of production is for final consumption. Therefore, total demand is equivalent to total supply. If people's consumption preferences stay the same as today and developing countries follow the same pattern favoring high-carbon-intensity commodities, there will be no way to reduce greenhouse gases.

Currently, "embedded carbon" (also called "embodied carbon" or "transferred carbon") has become an important concept, and this becomes more and more prominent with the accelerating rate of globalization and specialization after World War II. This may be illustrated by a simple example as follows. For example, country A provides capital (K), country B provides labor (effective labor, defined as EL), country C provides energy inputs (E), while the firm itself is built in country D and greenhouse gases are also produced in country D during the production process. In this situation, one can see that it is due to the consumption of some countries that causes the great emissions of country D. However, it could be possible that commodities are eventually consumed mostly in country E. Obviously, when determining the level of responsibility of each country, it is unfair to simply refer to domestic GHG emissions in one country regardless of the carbon emissions embedded in commodities and consumed by other countries.

Figure 3. Carbon Emissions Embodied in International Trade



Note: CO2 emissions embodied in exports (blue) and imports (orange) are shown as a percentage of total domestic emissions.

Source: Peters and Hertwich, 2008

Many researchers have paid much attention to the unbalanced production and consumption locus, however, their research is only focused on international trade flow, or rather, the transferred emissions of one country that can be obtained by calculating the emissions from the goods of net export. For example, Peters and Hertwich (2008) calculate the trade related emissions of all countries in 2001, and find that these emissions are quite large and different among countries (Figure 3). There is also similar research focusing especially on the embedded emissions of China, all of which point that the emissions embodied in net exports contribute much to the total emissions of China (Table 1). However, there are limitations to all of this research. First, by mainly adopt Input-Output analysis such research merely obtains the cross-section result, however, although each country export embedded emissions can be derived from the I-O table data of this country, they don't differentiate the consumption goods and intermediate goods. More important, fixed capital investment together with consumption and export is treated as the final demand in the Input-Output analysis(Weber, Peters, Guan and Hubacek, 2008), which may

underestimate the embodied emissions in trade in a dynamic economy. Kainuma, Matsuoka and Morita (2000) also compare the General Equilibrium analysis and Input-Output analysis when calculating embodied CO₂ emissions and find the former is better especially dealing with the change of consumption structure and the policy effects. Second, by relating embedded emissions to international trade, it is very likely to result some trade protection effects, or these results maybe used by political trade conservatists, and may arise effects contradicting with the WTO principles. Last but not least, the research does not directly point out how consumption causes such large levels of GHG emissions as well as how the problem depends on the mode of consumption per se.

Table 1. A Summary of Embedded Carbon Emissions Study for China

Researcher	Publication Source	Major Research Results
Bin Shui & Robert Harriss (NARC)	Energy Policy, 2006	About 7 to 14 percent of CO ₂ of China is embodied in the goods exported to USA from 1997 to 2003
Tyndall Center of Britain	Research report	About 1.1Gt CO ₂ are embodied in net export of China in 2004, which are 23 percent of total domestic emissions.
Pan Jiahua (CASS)	Research report	In 2006 the CO ₂ embedded net export of China are more than 1Gt, where 1.85Gt CO ₂ are in export and 0.8Gt CO ₂ are in import.
Christopher Weber, Glen P. Peters, Dabo Guan & Klaus Hubacek	L. Energy Policy, 2008	In 2005, around one-third of Chinese emissions are due to production of exports, and this proportion has risen from 12% in 1987 and only 21% as recently as 2002. It is likely that consumption in the developed world is driving this trend.

2.1 The Model

Given the above, we propose a new accounting framework for calculating consumption-based accumulative GHG emissions. A one-sector economic-growth model is adopted based on the following assumptions:

- 1) All countries are in the global market economy, where the different factors of the countries, together with the demand structure, determine relative prices and trade patterns across countries.
- 2) Factors can be flexibly allocated in the world, especially capital. Multinational

corporations choose where to produce in the world based on maximizing their profit. This makes the production function and marginal product of factors the same in different countries. Only the different structuring of factors across countries determines in which countries different goods are produced.

3) All investment will eventually be turned into consumption. At the same time, it is assumed that during some periods a great amount of investment is required for urbanization and public goods in every country. In this way, consumed good will eventually be used to place responsibility for GHG emissions as embodied in capital.

The detail theoretical model is described as follows:

1) Households

In this model we assume one representative household model. In each period, the endowments are: physical capital K_{it} , effective labor H_{it} and energy inputs LE_{it} . K_{i0} , H_{i0} and E_{i0} are given in the first period, and LE_{it} and E_{it} are set exogenously to grow at the growth rates h and n , K_{it} is the policy variable in our model. Each household also has the exogenous stock share of each firm, θ_{ij} . Thus a rational household will maximize its intertemporal utility as given in equation 1.

$$\max \sum_{t=0}^{\infty} \beta^t U(C_{it}) \quad (1)$$

Given interest rate r_t , effective wage rate w_t and energy price p_t , the representative household needs to provide production inputs and receives income, and receives dividend from the firms, then make a decision upon its consumption and investment, thus the budget constraint can be represented as:

$$C_{it} + I_{it} = r_t K_{it} + w_t LE_{it} + p_t E_{it} + \sum_j \theta_{ij} \pi_{jt} \quad (2)$$

If the depreciation rate of physical capital is δ , then the capital investment equation is equation 3.

$$K_{it+1} = I_{it} + (1 - \delta)K_{it} \quad (3)$$

2) Production

Let's assume the production market is perfect competition, in each period given the interest rate r_t , wage rate w_t and energy price p_t (product price is normalized as unity), producer will maximize its profit as equation 4 shows.

$$\text{Max}_{K_{jt}, H_{jt}, E_{jt}} \pi_{jt} = F(K_{jt}, LE_{jt}, E_{jt}) - r_t K_{jt} - w_t LE_{jt} - p_t E_{jt} \quad (4)$$

If we assume constant returns to scale, the profit of perfect competitive firms is zero.

Thus the total income is equal to the total outputs:

$$Y_t = F(K_t, LE_t, E_t) = F\left(\sum_j K_{jt}, \sum_j LE_{jt}, \sum_j E_{jt}\right) \quad (5)$$

3) Equilibrium

For factor market, the supply is equal to the demand for all the inputs (eq. 6)

$$\sum_i K_{it} = K_t, \sum_i LE_{it} = LE_t, \sum_i E_{it} = E_t \quad (6)$$

The commodity market is also in equilibrium, so we have:

$$\sum_i C_{it} + \sum_i I_{it} = F(K_t, LE_t, E_t) \quad (7)$$

4) Greenhouse Gas Emissions

If the ultimate goal of investment is for consumption, then we can assume when the physical capital is consumed in production process, carbon emissions deposited in these physical investments will release δK_t amount of emissions out of the total emissions to produce these physical capital, in which some are put into consumption, and some are put into new investment. If the GHG emissions deposited in physical capital is G_t^K in period t, and allocated to investment and consumption are G_t^I and G_t^C respectively, then the stock and flow relationship can be denoted in equation 8.

$$G_{t+1}^K = G_t^I + (1 - \delta)G_t^K, \quad G_0^K \text{ is given} \quad (8)$$

Secondly, in each period consumption and investment will release GHG emissions at $G_t^E + \delta G_t^K$, and in which GHG emissions from investment can be derived as:

$$G_t^I = \frac{\sum I_{it}}{Y_t} (G_t^E + \delta G_t^K) \quad (9)$$

Thus GHG emissions emitted directly from consumption can be derived as:

$$G_t^C = \left(1 - \frac{\sum I_{it}}{Y_t}\right) (G_t^E + \delta G_t^K) = \frac{\sum C_{it}}{Y_t} (G_t^E + \delta G_t^K) \quad (10)$$

Therefore each household produce GHG emissions due to consumption at:

$$G_{it}^C = \frac{C_{it}}{\sum_i C_{it}} G_t^C \quad (11)$$

Finally, in the period of between t_1 and t_2 , all the GHG emissions from the consumption satisfy the following equation:

$$G_{t_1}^K + \sum_{t=t_1}^{t_2} G_t^E = G_{t_2}^K + \sum_{t=t_1}^{t_2} \sum_i G_{it}^C \quad (12)$$

in which the left hand side means the GHG emissions deposited in physical capital at t_1 and sum of all the GHGs combusted from energy inputs, the right hand side denotes the emissions deposited in physical capital at t_2 as well as sum of GHG emissions for household consumption.

When the time horizon is long enough, we can see that equation (12) can be simplified as $\sum_{t=t_1}^{t_2} G_t^E = \sum_{t=t_1}^{t_2} \sum_i G_{it}^C$, in which case the GHG emissions deposited in first period and last period can be ignored.

2.2 Preliminary Results of Consumption Based Carbon Accumulative Emissions

Based on the above theoretical model, we calculate accumulative consumption-based carbon emissions from 1950 to 2005 for each country, as well as the related ratio of the global consumption emissions. Although currently about 24% of GWP-weighted GHG in the year 2000 are comprised of the non-CO₂ GHG, which include methane (CH₄), nitrous oxide (N₂O), and a number of high global warming potential (high GWP) fluorinated gases (USEPA, 2006a, 2006b). For this study, due to the data limitation, we only provide accumulative carbon emissions here for this preliminary study.

The database used for calculating these data has been assembled from a variety of publicly available sources. The emissions component is compiled from the World Resources Institute (1950-2004 data) and the US department of Energy's Energy Information Administration (2005 data). The database of PPP and consumption is taken from Maddison's statistics and the IMF's IFS, respectively. The rest data are taken from World Bank's WDI. With such, the results of this calculation for selected countries and groups of countries are shown in Table 2. Additionally, the domestic emissions of the countries and groups are also shown.

Table 2 suggests that, there is a great difference between accumulative consumption emissions and domestic emissions for most countries. For most developing countries with abundant energy endowments, such as China, South Africa, Iran, Russia and most of other EITs, consumption-based emissions are much smaller than domestic emissions. This also applies to Australia and Canada as they are developed countries with abundant energy endowments. However, for most developed

countries such as Japan, the United Kingdom, France, and Italy; consumption emissions are much larger than domestic emissions. This is because most rich countries consume more emission-intensive goods, whereas most developing countries with abundant energy supplies produce most of these commodities, which are inconsistent with the emissions embodied in trade shown in figure 3 over a much longer period.

Table 2. Global percentage shares of accumulative domestic emissions and accumulative consumption emissions 1950-2005 for selected countries and groups of countries (%)

Country group	Domestic emissions	Consumption emissions	Country group	Domestic emissions	Consumption emissions
Japan	4.80	6.60	United States	26.42	23.93
United Kingdom	3.55	4.22	China	10.19	6.84
France	2.26	3.95	Germany	5.64	4.90
Italy	1.82	3.47	Russian Federation	9.31	3.68
India	2.64	4.33	Canada	2.20	1.96
Brazil	1.00	2.72	Australia	1.20	1.10
Mexico	1.24	1.92	Poland	1.90	0.94
Spain	1.02	1.68	Ukraine	2.35	0.86
Argentina	0.56	1.11	Iran	0.86	0.77
Turkey	0.57	1.08	South Africa	1.33	0.58
High income	57.52	60.45	Romania	0.70	0.31
Lower middle income	20.71	23.12	Kazakhstan	1.03	0.49
Low income	2.29	4.25	Upper middle income	19.44	12.19
Non-Annex I	29.75	34.29	Annex I	70.21	65.72
EU 27	22.48	25.47	EITs	19.50	9.21

Still, the consumption emissions of some rich countries such as Germany and United States are a little larger than domestic emissions. The consumption emissions of developing countries such as India and Brazil are much larger than domestic emissions as well. This can be explained by following two arguments. On the one hand, Germany and the United States possess the most advanced manufacturing sectors, and export a great deal of emission-intensive manufactured goods by importing high levels of energy and resources. Also, there are trade surplus over a very long period of time between 1950 and 2005, whereas the result in Figure 2 is calculated by a static model. Quite oppositely, India and Brazil export a great number of primary products and resources in exchange for foreign manufactured goods. On the other hand, the current input-output analysis may underestimate the

difference between consumptions emissions and domestic emissions of these countries for lack of analysis on the emissions embodied in investment into the production of consumption goods.

From the discussion above, it is fair to determine each country's respective responsibility based on consumption emissions rather than their domestic emissions, since it is not firms' production, but the excessive and luxury goods consumption that should take responsibility for increased emissions. In practice, this concept can make sure that policy for mitigation does not deviate from consumption. For example, if government wants to adopt a carbon tax, it should use the employed tax instrument to correct people's consumption behaviors and life styles, and then indirectly change producer behaviors from balancing demand and supply. However, the current consumption emissions are analyzed based on every country's total consumption. It is assumed that the consumption emissions are proportional to total consumption. We don't differentiate the structure of the consumption. Different consumption goods may have different emission intensities, which need further investigation.

3. Developmental Rights and Mitigation Responsibilities

To achieve significant reductions in GHG emissions, a self-enforcing climate agreement needs to broaden participation and increase mitigation goals. Currently, the OECD countries, a few big developing countries (China, India and Brazil), Eastern Europe, Russia and Ukraine, account for most of the current and future GHG emissions. An international climate agreement involving only a subset of the world's emitters, will lead to carbon leakages in non-participant countries, resulting in emissions in excess of desirable global targets. To guarantee wide-ranging adoption, and break the current North-South climate negotiation impasse, it is important to work out a fair framework for an alliance of both the North and South. Since the North itself cannot stabilize the climate without the full commitment of the South, and the South cannot agree with any commitment if it will jeopardize its development. Thus an equitable and effective burden-sharing allocation system based on UNFCCC's "common but differentiated responsibilities" is necessary to ensure the rich countries not only deepen their own mitigation targets for the historically huge emissions, but also do whatever they can to help the poor countries develop, increasing poor nations' capacity to adapt and mitigate emissions for a low-carbon future.

3.1 A Revised Greenhouse Development Right (GDR) Framework

Baer, Athanasiou and Kartha (2007) first proposed a new burden-sharing framework - the Greenhouse Development Rights (GDR) Framework, which considers both sustainable development and equity issues for LDCs, by defining Capacity (C), Responsibility (R) and using Responsibility and Capacity Indicator (RCI) as a weighting product of the two.

Capacity (C) refers to a measurement of resources to pay without sacrificing necessities, which can be described as:

$$C = P \int_{y_{DT}}^{\infty} (y - y_{DT}) f(y, \bar{y}, G) dy \quad (13)$$

Where, P is the population, y_{DT} is the development threshold, $y - y_{DT}$ is the capacity of an individual with income y . \bar{y} is the per capita income, G is the Gini coefficient, and the income satisfies log-normal income distribution $f(y, \bar{y}, G)$.

While responsibility (R) indicates one nation's contribution to the climate problem considering historical reasons, which can be described as:

$$R = P \int_{y_{DT}}^{\infty} (e(y) - e_{DT}) f(y, \bar{y}, G) dy \quad (14)$$

Where, $e(y)$ is emissions at a given level of income, and e_{DT} is equal to the emissions of a person whose income is precisely equal to the development threshold. The quantity e_{DT} behaves analogously to the development threshold, as the "emission threshold", such that only emissions above this threshold contribute to R .

Therefore math formula of RCI is given in equation (15).

$$RCI = R^a \cdot C^b \quad (15)$$

Where a and b are the weight of responsibility and capacity, respectively, which satisfies the condition $a + b = 1$.

In this paper, when defining each country's burden share, we adopt Baer, Athanasiou and Kartha's idea (Baer et al., 2007), but make four main revisions to the calculation of RCI. First, we use a more comprehensive historical accumulative GHG emission data from 1850 to 2005 rather than the emission data from 1990-2005 used by them. It has been convincingly argued that all carbon emissions since the Industrial Revolution accumulatively bear responsibility for the current climate problem. Second, each country's accumulative emissions are represented not by its domestic emissions, but rather its consumption-based emissions. Each country's consumption-based emissions are the sum of its emissions from two periods: 1810-1949 and 1950-2005. In the former, each country's consumption emissions are equal to its domestic emissions because of low-level international trade and missing data for this era. In the latter each country's consumption emissions are following the method and preliminary results described in section 2.1 and 2.2. Third, the responsibility's weight is changed from 0.4 in their work to be 0.6 and the capacity's

weight is changed from 0.6 to 0.4 to further emphasize the widely agreed principle that whoever emits more GHG should take more responsibility. Last but also important, we don't regard this R-GDR framework as a protocol forcing countries to take part in an immediate forced mitigation. Rather, the framework should be seen as a basis on which each country's action blueprint can be described and directed to facilitate a global deal in international finance flow and technology transfer, made and shared among countries. Although each country has the responsibility and capacity, to maintain their mitigation burden share in this framework, it needs a supplemental standard to determine whether a country should take part in an immediate forced mitigation or not.

Table 3. Global percentage shares of capacity, accumulative consumption emissions, responsibility and RCI for selected countries and groups of countries (%)

Country & Group	Capacity	Consumption Emissions	Responsibility	RCI (M-GDR)	RCI (GDR)
United States	33.7	27.5	38.9	37.4	36.0
Japan	9.4	5.3	6.7	7.8	27.8
EU 27	30.5	29.8	36.3	34.0	4.3
United Kingdom	4.7	6.8	8.7	6.9	5.9
Germany	6.1	6.6	8.4	7.5	3.6
France	4.5	4.2	5.4	5.1	1.7
Australia	1.7	1.0	1.3	1.5	8.4
Russia	2.0	3.6	2.2	2.1	1.9
Brazil	2.2	2.2	1.6	1.8	2.9
China	2.3	5.6	1.2	1.6	2.7
India	0.1	3.7	0.0	0.0	0.1
South Africa	0.5	0.6	0.4	0.5	0.8
Annex I	81.9	71.7	89.6	87.2	81.7
Non-Annex I	18.1	28.7	10.4	12.8	18.3
High income	84.3	66.2	87.5	86.3	83.3
Upper middle income	8.7	11.2	7.6	8.0	9.9
Lower middle income	6.9	19.4	4.8	5.6	6.6
Low income	0.1	3.6	0.1	0.1	0.1

Based on the revisions above, we can estimate the country's total RCI, and compare it with the global total to calculate each country's share. In the R-GDR's calculation we adopt the database in 2005 following Baer, Athanasiou and Kartha(2007), except the consumption emissions database. The results of this calculation for selected countries and groups of countries are shown in Table 2. It can be seen that the United States and EU27 contribute the most; about 37.4% and 34.0% respectively. Overall, high income countries or Annex 1 countries at the current time need to contribute 86.3% and

87.2% respectively. But for most developing countries, such as China, India, Brazil and South Africa, each burden share is very small. Therefore, though lower middle income and low income countries possess one-fourth population and almost a quarter income and consumption emissions, their total share of the burden is very tiny; not more than 6%.

3.2 Cap and Allocation (and International Transfer)

After the calculation of RCI, we can use it to distribute permits to each country under a cap-and-allocate system. This work is the same as Baer, Athanasiou and Kartha(2007) except the RCI.

First, the global mitigation requirement is the difference between a global baseline trajectory (constructed as a bottom-up aggregation of national baseline trajectories) and the 2 °C emergency trajectory. Figure 4 illustrates the global emissions pathway for three emergency scenarios, along with each scenario's estimated risk of exceeding the 2 °C threshold. We select the most stringent (the lowest risk in red) 2 °C emergency pathway as the goal that the new protocol is to attain. It has emissions peaking in 2013 and dropping off at a resolute 5.2 percent per year, reaching a level of 80 percent below 1990 levels in 2050. In Figure 5, we show two global emissions projections based on a "business-as-usual" trajectory and a "no regrets" trajectory. The former extrapolates the historical approach to energy conservation, renewables, fossil fuel subsidies, pollution control, etc, while the latter is a projection as it would be if all cost-benefit, negative- and zero-cost, emissions reductions were successfully captured. So the "no regrets" reductions (the green wedge in Figure 5) represent free and profitable reductions.

We argue that a country's "no regrets" trajectory should be adopted as its national baseline. That is to say that all nations should be responsible for capturing their own "no regrets" reductions first, and that only further reductions, the difference between "no regrets" trajectory and the 2 °C emergency pathway, should count toward discharging a national mitigation obligation. Given this baseline projection and this 2 °C emergency pathway, the global mitigation burden over the period 2013-2030 would amount to 283GtCO₂ of emissions reductions.

Figure 4. Global emissions pathway for three emergency scenarios, along with each scenario’s estimated risk of exceeding the 2 °C threshold

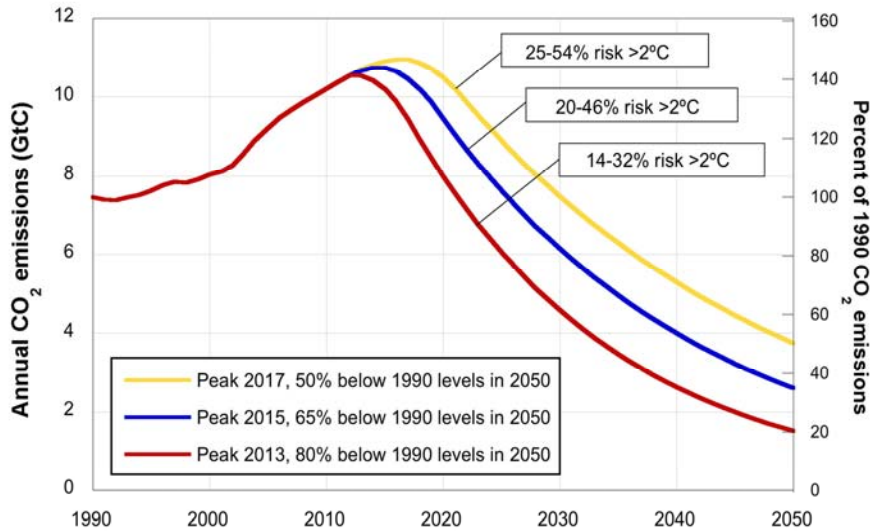
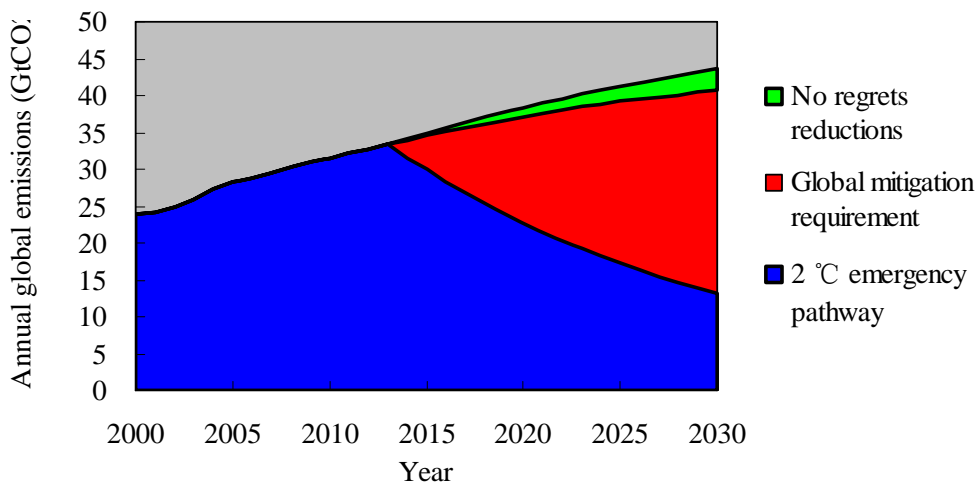


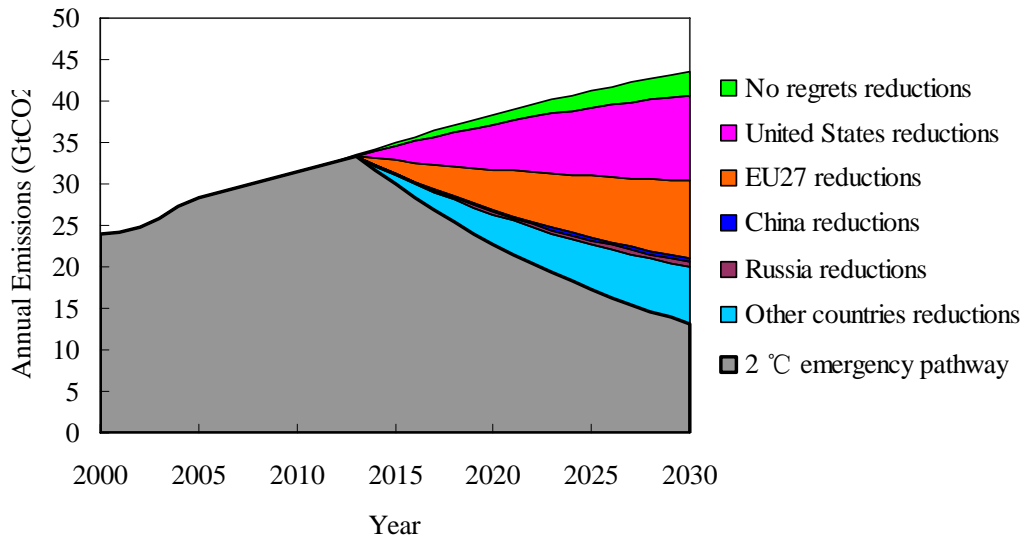
Figure 5. The mitigation gap (red wedge) between a “no regrets” baseline (border of red and green) and a 2 °C emergency pathway (border of red and blue)



Second, this global mitigation requirement is divided into national mitigation obligations. Each country – however rich or poor it may be – is allocated a portion of the global mitigation requirement, in proportion to its aggregate national RCI. Graphically, the global mitigation burden can be divided into wedges, as in Figure 4. They show countries and the gigatons of reductions they are obligated to pay for. Thus the United States’ wedge is 37.4 percent of 283 GtCO₂, or about 106 GtCO₂, while the European Union’s wedge is 34.0 percent, or about 96 GtCO₂. Russia, a middle-income country, gets 2.1 percent, or about 6 GtCO₂, and China, a great

developing country, gets 1.6 percent, or about 4.9 GtCO₂.

Figure 6. Mitigation requirement, divided into “obligation wedges” that reflect national / regional shares of RCI



Third, each country determines how to fulfill its obligation, domestically and internationally. We will examine two examples: the US and China. For the case of the US in figure 6, it shows US emissions and obligations projected out to 2030. If the US reduction obligation were interpreted literally and achieved entirely through domestic mitigation, it would imply reductions of nearly 190% below 1990 levels by 2030, and a US emission level of minus 4 GtCO₂ by 2030. Obviously, for a mitigation obligation of this magnitude to make sense, the US must not be expected to meet its entire obligation through domestic reductions. Whatever is not accomplished domestically, the US would need to fulfill internationally, by way of reductions in other countries that are “supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner”. Figure 7 shows the total US reduction obligation with an indicative division into a domestic mitigation effort and an international mitigation effort. Even if the US reduces its emissions by 5.4 percent per year starting in 2013, which achieves physical domestic reductions by 2030 of more than 54% below 1990 levels, it satisfies far less than half of the US’s total obligation. The remainder must be made in other countries. Therefore, to fulfill the obligation of 108 GtCO₂ by 2030, the US would domestically reduce 38 GtCO₂ and provide funding internationally for the reduction of the remaining 68 GtCO₂. China, in contrast, is obligated to total reductions of less than 5 GtCO₂ by 2030, all of which could be made domestically (see figure 8). At the same time, a much larger quantity of reductions within China, more than 40 GtCO₂ 2013-2030, would be enabled and supported by other countries, those with higher capacity and responsibility. China’s emissions are large, and fully exploiting its mitigation potential is essential if we’re to keep within the 2°C emergency trajectory.

Figure 7. Mitigation requirement of US and the allocation between domestic mitigation and mitigation funded in other countries

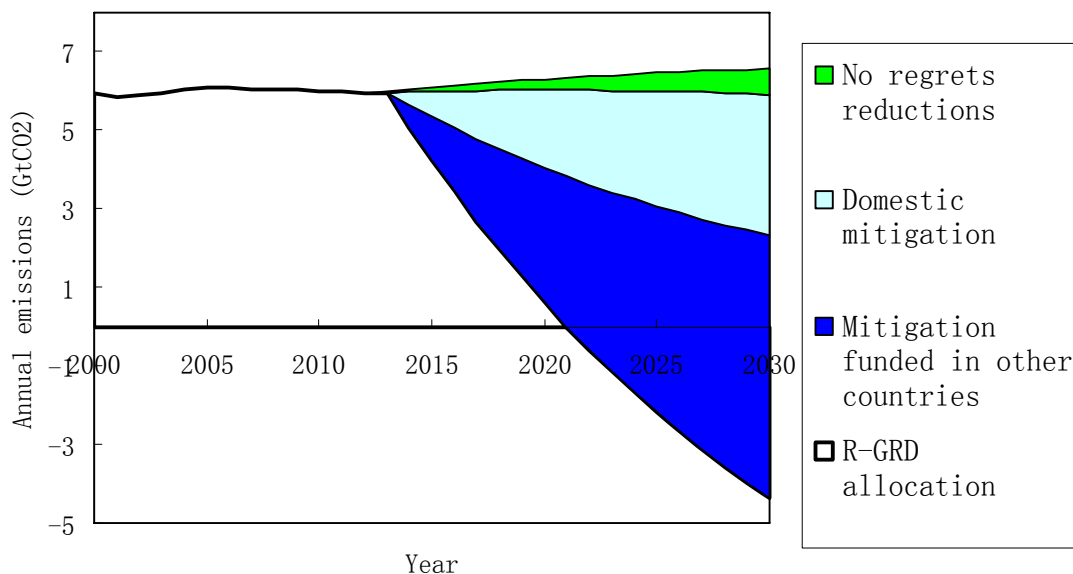
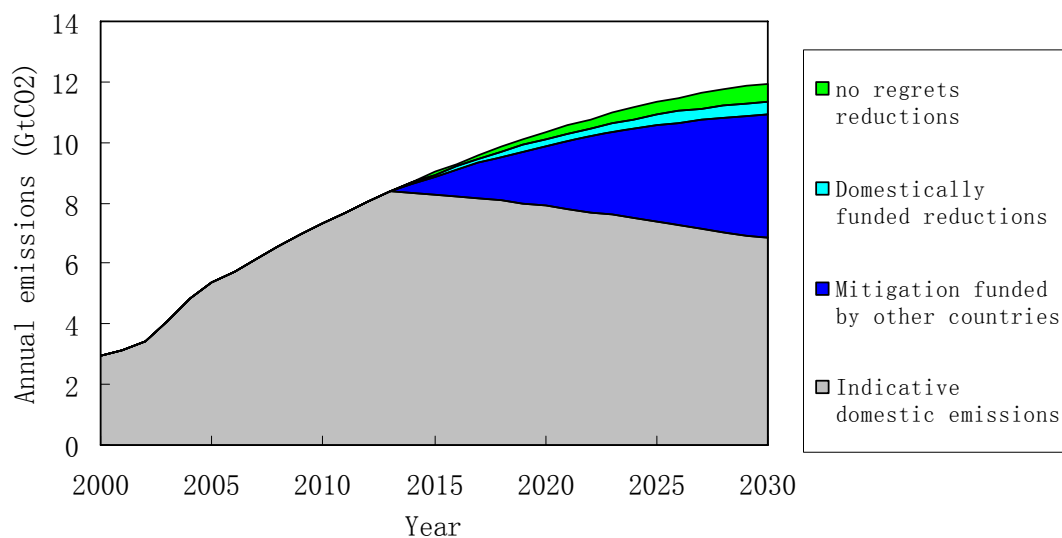


Figure 8. China domestically funded reductions and more mitigation funded by other countries



3.3 A Gradual Step-In Framework with Graduation Threshold

As discussed in the previous section, a gradually implemented project may be preferable to many developing countries. We argue that a reasonable graduation threshold should not be an arbitrary year or income per capita, but the emissions after which the country automatically makes forced mitigation. Time adopted as a threshold makes no sense. Based on the widely agreed principle, that whoever emits more GHG should take more responsibility, we think that income per capita is not as important as

emissions, and is not a good threshold. Emissions level is a natural threshold. If adopted, it will prompt people to consume less and emit less. Moreover, RCI, combined with income and emissions, may be a more reasonable threshold, though at the current stage might be difficult to be accepted by the policy makers when the post-kyoto climate architecture is not built up yet. Therefore, we suggest that the accumulative consumption emissions be the graduation threshold, so that countries can gradually participate in the faire regime based on M-GDRs.

Table 4. The accumulative domestic emissions per capita, cumulative consumption emissions per capita and income per capita for selected Annex I and Non-Annex I countries

Country	Accumulative consumption emissions		
	Annex 1=1	per capita (tCO ₂)	Income per capita (\$)
Bulgaria	1	228	9328
Croatia	1	263	13231
Germany	1	848	30445
Greece	1	314	29261
Japan	1	435	30290
Luxembourg	1	550	69776
Portugal	1	350	19956
Romania	1	144	9368
Russia	1	262	11861
Slovenia	1	442	23010
Switzerland	1	695	35182
Ukraine	1	190	5583
United Kingdom	1	1186	31371
United States	1	966	41813
Argentina	0	255	10815
Brazil	0	125	8474
China	0	45	4252
India	0	35	2230
Indonesia	0	61	3209
Korea, Rep.	0	186	21273
Mexico	0	162	11387
South Africa	0	136	8478
Turkey	0	128	10370

Concretely, we adopt the lowest accumulative consumption emissions 1850-2005 per capita (population in 2005) of Annex 1 countries' as the graduation threshold. It can be seen from table 4 that the graduation threshold is 144tCO₂ (Romania). So, the accumulative consumption emissions per capita of most developing countries, such as China, India, Brazil and Mexico, are less than this threshold. In contrast, the lowest income per capita in 2005 of Annex 1 countries' is 5583 \$ (Ukraine), respectively.

We have projected the accumulative consumption emissions per capita and income per capita (population in 2005) in 2015, 2020, 2025 and 2030 in a “business-as-usual” scenario and “non-regret” scenario for selected countries to determine when they will be forced to begin mitigation. As can be seen in Figure 9 and Figure 10, Argentina, Mexico, Turkey and Brazil will need to begin mitigation before 2015, and China will begin shortly before 2030. But India need not begin even in a long period after 2030. Moreover, we argue that if a country takes voluntarily mitigation now, it can delay the date when mitigation becomes compulsory. For example, if China devotes itself to mitigating the energy intensity by 20 percent in the 11th five-year plan and going on the mitigation during 2011-2020, which may mitigate the GHG emissions indirectly and can be regarded as voluntary mitigation, it will be possible to delay compulsory mitigation for 5-10 more years. Under such condition, China may not reach the threshold until 2040.

Figure 9. The projection in BAU scenario for selected countries in 2015, 2020, 2025 and 2030

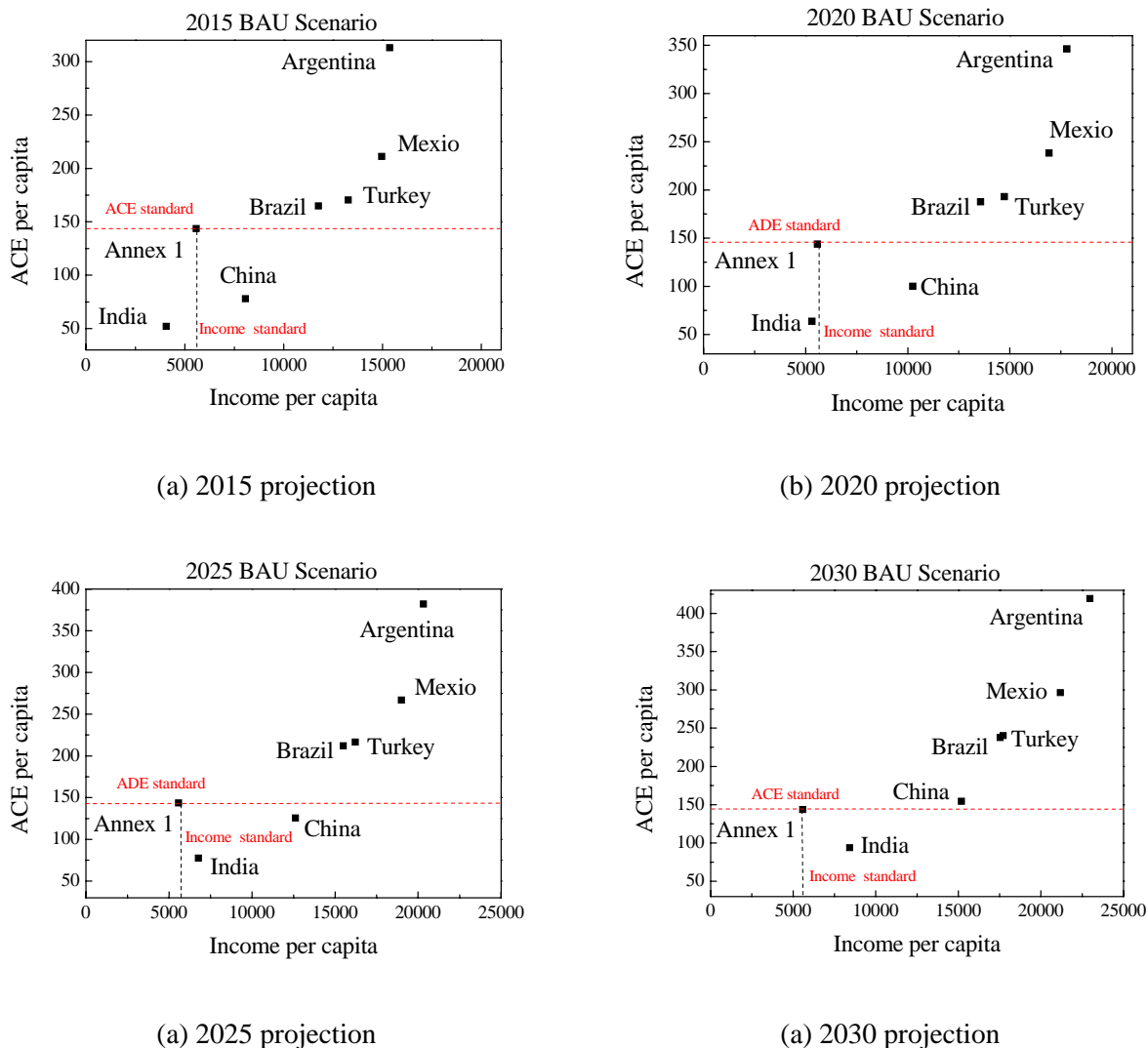
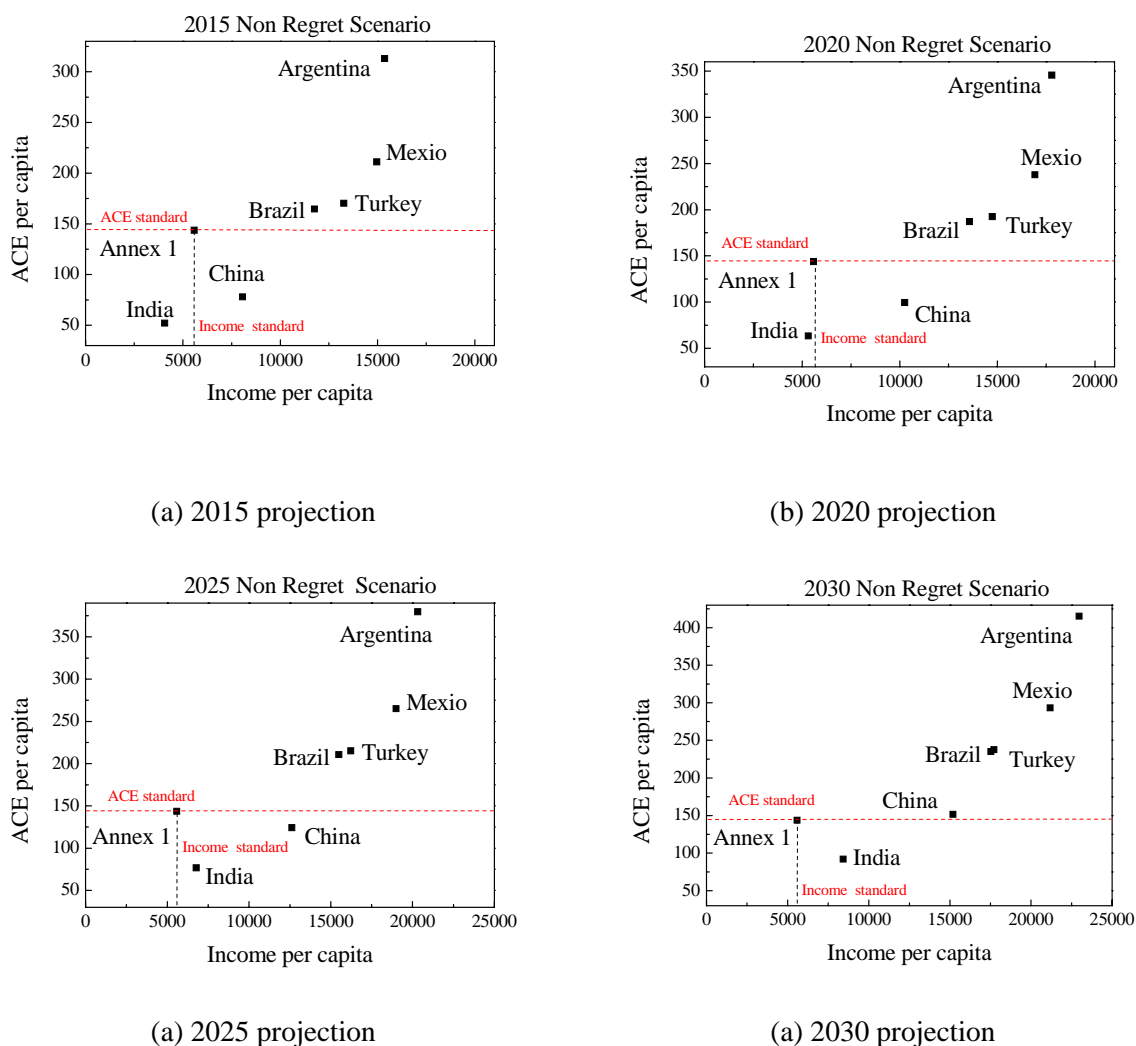


Figure 10. The projection in non-regret scenario for selected countries in 2015, 2020, 2025 and 2030



3.4 Proposed “Climate Treaty” Regime for Post-2012 Climate

Architecture

Based on the analysis above, we suggest a climate treaty for combating future climate change. The main points of this proposal are presented as follows:

- 1) Each country’s responsibility is calculated based on the accumulative consumption emissions.
- 2) Each country’s capacity is calculated by considering the income level and the income distribution, which means some people in each country whose income is beyond some threshold should always contribute to mitigating this problem.

3) We don't regard this R-GDR framework, calculated by combining responsibility and capacity, as a protocol that each country should be forced to adopt immediately, but a basis on which each country's action blueprint can be described and directed leading towards a global deal in international finance flow and technology transfer that is satisfactorily made and shared among countries; while simultaneously ensuring that each country has a responsibility, capacity, and mitigation burden share in this framework.

4) The lowest accumulative consumption emissions 1850-2005 per capita (population in 2005) of Annex 1 countries' can be the graduation threshold, above which the country should automatically face compulsory emissions mitigation.

5) Meanwhile, countries under the graduation threshold are not compelled to mitigate, but they can engage in voluntary mitigation. This voluntary mitigation will inevitably benefit the nation by delaying the time when the threshold is crossed and mitigation becomes compulsory.

6) The countries under the graduation threshold can take part in international carbon trading. They can project their own mitigation trajectory, take part in "the Inter-country Joint Mitigation Plan", and engage in the mitigation project, technology transfer and financial transfer together with cooperating developed countries. These reductions in the emissions of countries under the graduation threshold will partially fulfill the cooperating developed countries' obligations under the framework.

7) The developed countries joining in the climate treaty should commit to corresponding technology transfers and financial assistance should be guaranteed.

8) If a country under the graduation threshold accepts international technology and financial transfers, it should reduce its graduation threshold correspondingly.

Part II. China's Mitigation Strategies, Policies and Institutions

4. "No-regrets" Carbon Mitigations and Voluntary Reductions

4.1 "No-regrets" Carbon Mitigations

"No-regrets" Emission Reduction refers to the reduction that will occur regardless of climate change. For example, we will "not regret" improving energy efficiency in order to enhance competitiveness. "No-regrets" Emission Reduction as an economic term can be defined as: the actions to achieve economic returns can be greater than input costs to achieve a certain degree of carbon emission reductions. The broadest definition of No-regrets Emission Reduction is the emission reduction corresponding to the achievement of the sustainable development of a country, which means: not only income growth, but also the improvement of the environment in line with national goals, constitutes part of the "benefit", and if the total benefits are greater than the input costs, the reduction is "No-regrets". The narrowest definition of No-regrets Emission Reduction is the actions that lower input costs, for instance, raising building energy efficiency standards. As it is difficult to forecast the costs and benefits of the majority of emission reduction actions, and as many costs and benefits are indirect, the narrowest definition of No-regrets Emission Reduction should be used when we discuss the national action program of emission reduction.

No-regrets Emission Reduction policy includes the following two aspects:

1) policies of energy conservation and energy efficiency improvement: to achieve the goal of a 20% reduction in energy consumption per unit of GDP in the "11th Five-Year Plan" period; and to decrease 20% in the energy consumption per unit of GDP every 5 years until 2020;

2) policies of optimizing the energy structure: in order to achieve the "No-regrets" target, the proportion of no-carbon energy in primary energy structure should increase from 7-8% in 2005 to 15% in 2020, the proportion of natural gas from 2-3% in 2005 to 9% in 2020, and correspondingly reduce the proportion of coal in primary energy.

According to the No-regrets Emission Reduction policies, if energy consumption per unit of GDP reduces 20% every 5 years up to 2020 and meanwhile the energy structure is continuously optimized, we estimate how the two policy options - energy intensity reduction and energy structure optimization – contribute to decrease carbon dioxide emissions per unit of GDP in each period (figure 11). The effects of GHG emission reductions are shown in Table 5.

Figure 11. Contribution of energy intensity reduction and energy structure optimization to decrease carbon dioxide emissions per unit of GDP

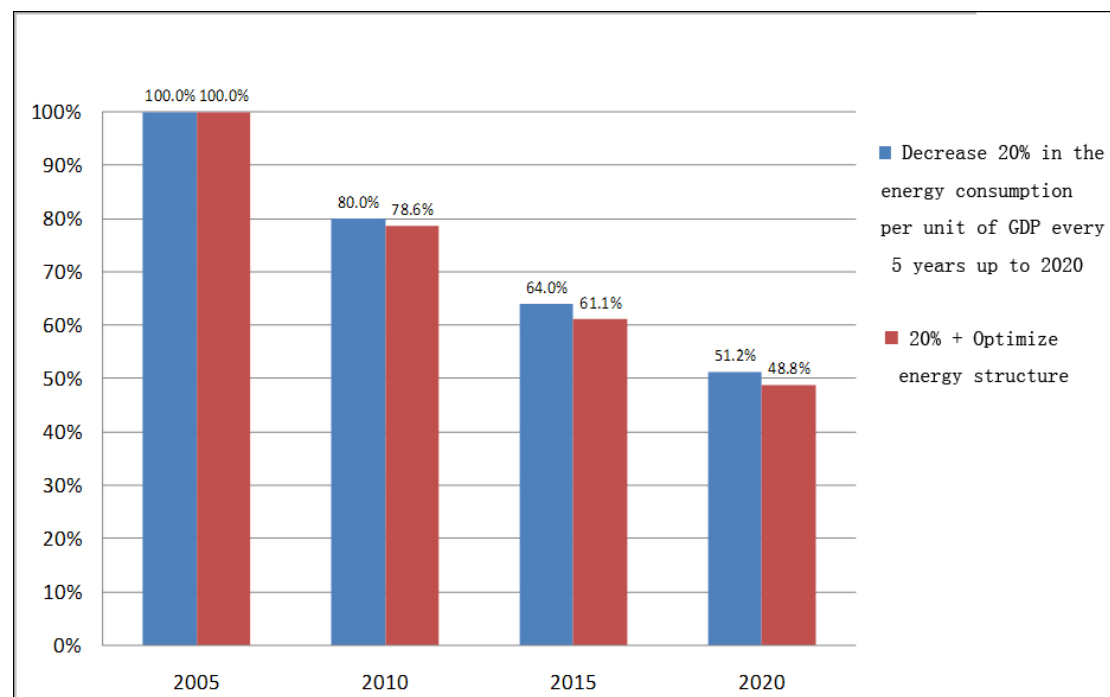


Table 5: The effects of GHG emission reduction according to No-regrets Emission Reduction policies

	2005	2010	2020	2005-2010* %	2010-2020* %
Total amount of emission, BAU (Gt-CO ₂)	5.25	8.65	18.30	10.5	7.8
Total amount of emission, Non regret (Gt-CO ₂)	5.25	6.8.11	8.94	5.3	2.8
GHG emissions per unit of GDP, Non regret scenario (t-CO ₂ /10000 RMB)	2.86	2.25	1.40	4.7	4.6

*Average Annual Growth Rate

4.2 China's Carbon Voluntary Reductions

The concept of voluntary emission reduction for developing countries is initiatively proposed and adopted emission reduction actions in developing country beyond Non-regret Emission Reduction; at the same time, in accordance with the principles of international agreements, the emission reduction activities also require developed countries with their obligations under UNFCCC to provide transfer of technology and financial resources to developing countries.

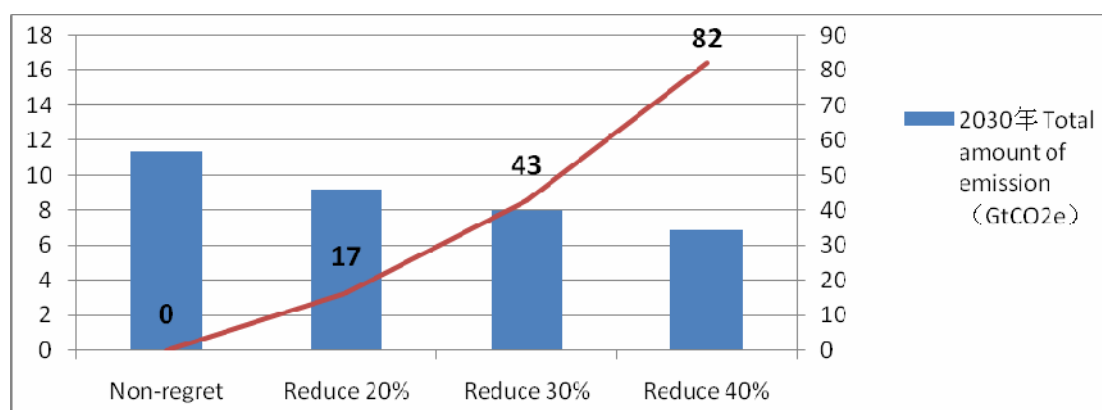
Taking the non-regret emission scenario as a baseline, we analyzed the cost inputs in different scenarios of GHG emission reduction. To facilitate research, we took the assumptions of voluntary emission reduction accounting for the total emissions in non-regret scenario of 20%, 30% and 40% in 2030.

Table 6: Voluntary emission reduction scenarios

Scenario	2020		2030	
	Total amount of emission (GtCO ₂ e)	Emission reduction amount (GtCO ₂ e)	Total amount of emission (GtCO ₂ e)	Emission reduction amount (GtCO ₂ e)
Non-regret	8.9	-	11.4	-
Reduce 20%	7.1	1.8	9.2	2.3
Reduce 30%	6.2	2.7	8.0	3.4
Reduce 40%	5.3	3.6	6.9	4.6

According to the three assumptions of the GHG emission reduction targets, and using McKinsey cost curve for GHG emission abatement measures, in order to realize the reduction targets by 20%, 30% and 40% of the GHG emissions in 2030, we need investment funds of 16.5 billion Euros/year, 42.8 billion Euros/year and 82.3 billion Euros/year. The investment increasing trend with the targets of GHG emission reduction is shown in Figure 12.

Figure 12. Investment in different emission reduction scenarios



To achieve 4.6Gt of carbon dioxide emission reduction in 2030 relative to the Non-regret scenario, there are still many obstacles, such as: really applying and deploying foreign advanced reduction technologies in China needs to promote long process, in particular, there are many obstacles in the technology transfer; otherwise, a new emission reduction technology needs a large initial investment, and there is market failure, so if there is no international funding to promote the deployment and application of new emission reduction technologies, the difficulties in reality are beyond the results of theoretical cost-benefit analysis.

5. China's Climate Change Compatible Energy Strategy

5.1 Impacts of Different Energy Policies on GHGs Emission

Under the circumstance of providing the same amount of energy services, different energy technologies produce different amount of GHG emissions due to the differences on energy varieties, energy utilization efficiencies, GHGs control technologies and costs.

Only GHGs Emission from Fossil Fuels: Taking coal as a reference and assuming that providing the same heat value of energy services, use of oil can reduce 18% of CO₂ emissions and natural gas 37% among all the fossil fuels. There would be even no CO₂ emissions If using other carbon-free energy sources including primary power (power generation from renewable energies such as nuclear power, wind power, hydropower and photovoltaic power), biomass energy and solar energy, etc.

Impacts of Energy Efficiency: 1% improvement of energy efficiency can reduce emissions by 1%. Energy conservation and energy efficiency will help to guide rationally the end-consumption and to control GHGs emissions by reducing energy demand. Compared with previous studies, the Fourth Assessment Report of IPCC in

this year's emphasizes more on the essential role of energy conservation in GHGs emission reduction.

Now coal continues to take up to more than 2/3 in China's primary energy structure. Therefore, the development and efficient utilization of clean coal technology is crucial to control GHGs emission in China in the future. In order to effectively reduce GHGs emission, we must rely on scientific and technological progresses, speed up non-fossil energy technology development such as renewable energy and nuclear energy, and at the same time follow-up studies of advanced power generation technologies such as CCS (Carbon Dioxide Capture and Sequestration) which can be implemented together with IGCC and NGCC. CCS is an end-treatment technology. It can reduce CO₂ emissions by 80-90% but meanwhile increase electricity consumption by 14-25%, resulting in the increased cost for electricity by 21-78%. Therefore, CCS will reduce the efficiency of power generation, increase primary energy consumption and rise energy supply cost sharply. Medium to long term, CCS costs may tend to gradually decline to an acceptable level if the maturity and promotion scale of the technology can be improved.

5.2 Suggestions on China's Energy Strategy Measures of GHG

Emission Mitigation

Due to the close connection between global climate change and national energy strategy & national economic development, climate change issue will increasingly become an important factor influencing national energy strategy making. China's future energy strategies must be a sustainable energy development system which can meet the needs of China's economic and social development. It must advance with the times, conform to national conditions, be future-oriented and comprehensively consider demands, resources, environment, technology, economy and other factors from a world's point of view. Suggestions on China's energy strategy measures of GHGs emission mitigation include:

Firstly, build up a sustainable energy strategy framework. In 2004, the State Council adopted the "Medium and Long-Term Energy Development Planning Framework (2004-2020)" (draft). In 2004, the National Development and Reform Commission issued China's first "Special Medium-Long Term Item Program of Energy-Saving". In February 2005, the Chinese National People's Congress examined and adopted the "Renewable Energy Law," clarified the responsibilities and obligations of the government, enterprises and users in renewable energy development and utilization, proposed a series of policies and measures including Total Amount Target System, Grid-Connected Power Generation System, Price Management System, Cost-Sharing System, Special Funds System and Preferential Tax System, etc. In August 2005, the State Council issued the "Notification on Performing Recent Priority Works in order to build up An Economizing Society" and "Several Advices on Accelerating Circular

Economy Development". In December 2005, the State Council issued "Decision on Issuance and Implementation of 'Provisional Regulation on Promoting Industrial Structure Adjustment' " and "Decision on Implementing the Scientific Approach of Development and Enhancing Environmental Protection". In August 2006, the State Council issued "Decision on Strengthening Energy Conservation". Under the global trend of gradually addressing climate change as the main goals of energy strategy, China should make efforts to build a stable, economic, clean and safe energy supply system as well as to provide policy and legal guarantees for further enhancement of China's ability to cope with climate change.

The Chinese government should, according to new problems and new changes, establish Scientific Approach of development, accelerate building up a resource saving and environmentally friendly society, and further enhance policies and measures related to climate change.

Secondly, constantly work on energy conservation and emission reduction. Energy conservation is the realistic choice for China to alleviate resource constraints and mitigate GHGs emission. China should reduce the GHGs emission through constant energy conservation and significantly improved energy efficiency. This is a long-term strategic policy for China's national economic development. It is both a very urgent task currently as well as an urgent need required by addressing global climate change. We should further clarify the goal of energy conservation and energy consumption reduction in terms of targets and overall requirements, adjust and optimize energy structure, fully implement key projects, accelerate circular economy development, speed up technology development and promotion, strengthen management of energy conservation and energy consumption reduction, enhance supervision and inspection of law enforcement, improve policy incentive and restrain mechanisms, improve public's awareness about conservation, and function government's leading role. We should also promote actively the implementation of the Ten Key Energy-Saving Projects including Industrial Coal-Burning Boilers (Kilns) Reformation, Regional Co-Generation, Utilization of Waste Heat and Pressure, Saving and Substituting for Oil, Energy Saving in Electric System, Energy System Optimization, Energy-Saving in Buildings, Green Lighting, Energy-Saving in Government Agencies, and Energy-Saving Monitoring and Technology Service Construction. Progresses and effects of these projects should be guaranteed in order to form stable energy-saving capacity as soon as possible. Through the implementation of the above-mentioned Ten Key Energy-Saving Projects, it is expected that during the "11th Five-Year Plan" period, 0.24 billion tons of standard coal can be saved, which equals to 0.55 billion tons of CO₂ emission reductions.

Thirdly, vigorously adjust and optimize energy structure. According to the analysis above, China's prioritized energy development strategy in the future should be vigorously adjusting and optimizing energy structure through increasing the share of low-carbon and carbon-free energy utilization. Optimizing structure of primary

energy supply and reducing CO₂ emission intensity per unit energy consumption are of great help to improve energy efficiency of the whole national economy. The emission intensity should be minimized based on meeting the energy demands of economic and social development. We should orderly develop hydropower, considering which as an important means to promote the energy structure transformation toward a clean & low-carbon direction but not to sacrifice ecology at a cost; we should actively promote nuclear power construction and gradually increase share of nuclear in total primary energy supply, considering which as an important component of national energy strategy; we should greatly develop coal-bed methane/coal mine methane (CBM/CMM) industry and minimize energy waste and methane emission during the production of coal through CBM/CMM exploration, development and utilization in order to accelerate restructure of coal industry, reduce accidents, improve resource utilization rate and prevent pollution; we should vigorously promote biomass energy development and utilization through prioritizing biomass power generation, biogas and solid & liquid biomass fuels; we should also positively support development and utilization of wind, solar, geothermal and marine energies.

Fourthly, China must give close concern on the main trend of global energy technology development and clearly define its own direction when making energy development strategies. At present, China's energy technology development is accelerating and gradually shortening distance toward the world's advanced level. However, we could be deviated without connection to the rest of the world. Only following the development of energy technology led by developed countries and adjusting our direction timely can we avoid development in blindness and move forward to the advanced position of technology development. As the impact of climate change on energy technology development deepens, China should enhance researches and development of climate friendly energy technology in order to take a role in advanced energy technologies in the future.

6. Institution Arrangements for Low-Carbon Economy

Institutional factors such as system, policy and government actions are important measures for greenhouse gas emission reduction, including: improving institution for addressing climate change promoting multi-sectoral coordination mechanisms, allocating resources through economic means, improving relevant laws and regulations, adjusting industrial structure, mobilizing the public to participate in a wide range of actions to address climate change. If properly designed, such policies and measures will have a significant effect in both promoting sustainable development and controlling of greenhouse gas emissions.

6.1 Strengthen the responsibility of the government

Enterprises are the main source of greenhouse gas emissions. However, the government should take the primary responsibility for greenhouse gas emissions. Strengthen the government's responsibility is an important mean for emission reduction. Governments of all levels should integrate climate change into the economic and social development planning as an important part of implementing of Scientific Approach of Development and achieving sustainable development, establish proper regional and sectoral measures, enhance the ability of organization and implementation to address climate change. In addition, they should highlight the tasks of energy conservation and emission reduction and establish complete accountability system by forming strict and feasible system that regulates the indicators, procedures and results of the evaluation for governments' achievements in undertaking above tasks, enhance the synergies of the sustainable development policies on the control of greenhouse gas emissions. Two specific measures are included as follows:

First, strengthen the leadership of central government on addressing climate change

The State Council has established a leading group on addressing climate change, which takes charge of critical strategies and policies on climate change. In addition, coordination between the central government and local governments should be enhanced to promote the smooth implementation of relevant policies and measures.

Second, establish local management agencies on addressing climate change, with clear responsibility for governments of all levels

Governments of all levels should integrate climate change into local economic and social development planning, establish local management agencies on addressing climate change, implement relevant China's National Climate Change Programme, form local expert groups on climate change and develop proper climate change related measures and policies according to the local geographical environment, climatic conditions, as well as the level of economic development

6.2 Allocate resources through economic means

Implement enterprise income tax preferential policies on eligible enterprises relevant to water-saving and energy-saving, as well as comprehensive utilization of resources in line with the Enterprise Income Tax Law. Adjust and improve value-added tax preferential policies for enterprises with the business of renewable resources recycling. Promote resources tax reform and mineral resources compensation, improve the manner and raise the standards of taxation. Implement tax preferential policies to encourage the importing of advanced energy saving equipments and its key components. Formulate economic policies to encourage the construction of land-saving, energy-saving and environment-friendly green buildings, as well as the

integration of solar energy and buildings. Study and establish tax policies for the purchasing of energy-saving and environment-friendly equipment of enterprise. Financial institutions should enhance the credit support for energy-saving projects and provide financial service to eligible projects while guarding against risk.

6.3 Improve the legal system

Improve regulations relevant to the mitigation and adaptation to climate change, and promote works on addressing climate change. Promote the implementation of the new promulgated China's National Climate Change Programme, and strengthen regulations and standards relevant to the mitigation of greenhouse gas in the areas of energy production and conversion, energy-saving, agriculture, forestry and solid waste, etc. Specific measures are as follows:

First, accelerate formulating and revising relevant regulations of energy production and conversion.

Formulate and promulgate Energy Law and get Coal Law, Power Law and other laws revised according to the principles of Energy Law. Enhance encouragement policies on the development of clean, low-carbon energy.

Second, improve energy-saving regulations and standards.

Improve Energy Conservation Law of the People's Republic of China. Constitute necessary supporting regulations such as Electricity-saving Management Regulation, Petroleum-saving Management Regulation, and Building Energy-saving Management Regulation; formulate and improve energy efficiency standards for main energy-consuming industrial equipments, domestic appliances, light appliances and motor vehicles, improve energy-saving design criteria of main energy-consuming industries, energy-saving standards for buildings, and accelerate the formulation of temperature control standards on building refrigeration and space heating. Take energy-saving standard of buildings for example, if residential and public buildings are strictly enforced to meet the standard of 50% energy-saving, with accelerating the reform of heating system and strengthening the efforts to technologies and products of energy-saving buildings simultaneously by 2010, 50,000,000 tons of standard coal can be saved while 266,000,000 tons of carbon dioxide emissions can be reduced.

Third, strengthen the establishment and implementation of laws and regulations.

Gradually establish and improve the system of laws and regulations based on Law of Agriculture of the People's Republic of China, Law of Grassland of the People's Republic of China and Law on Land Management of the People's Republic of China, together with administrative rules and regulations, that can lead to improved agricultural production and increased agricultural ecosystem carbon storage; develop farmland and pasture protection construction plans, strictly control land reclamation in areas with fragile ecosystems, and forbid any destruction of pasture or waste of land

Forth, strengthen the implementation of relevant laws and regulations on forestry.

Formulate regulations on conservation of natural forests, regulations on transfer rights of forests, forest products, and forest land use, etc.

Fifth, strengthen the implementation of relevant laws and regulations on municipal wastes.

Strengthen the implementation of relevant laws and regulations, including, inter alia: Law on Prevention of Environmental Pollution Caused by Solid Waste of the People's Republic of China, Regulations on the Management of City Appearance and Sanitation, and Measures for the Management of Municipal Domestic Waste. The management focus will be shifted from the current end management to whole-process management, i.e. reduction of wastes from the source, recovery and utilization, and non-hazardous disposal. The processes of waste production and disposal will be normalized to the greatest possible extent, and the disposal of municipal domestic waste will be incorporated into the overall planning of the city. Further improve relevant sectoral standard. According to the evolving requirement, compulsory standards for wastes classification and recovery shall be formulated, so as to improve the comprehensive utilization of wastes resource and to reduce the amount of wastes from the source. The currently valid sectoral standards such as Standards for the Classification and Assessment of Municipal Domestic Wastes, Technical Norms on Sanitary Landfill of Domestic Wastes, Standards for the Assessment of Non-hazardous Landfill of Domestic Wastes, will be implemented more strictly and further revised, so as to improve the recovery and utilization of combustible gas from the landfills and to reduce the emissions of methane from landfills.

6.4 Industrial Structure Adjustment

The intensity of greenhouse gas (GHG) emissions is highly sensitive to the adjustment of industrial structure. We can significantly reduce GHG emissions through containing the growth of industries of high-energy-consumption and high-emission as well as eliminating backward productivity. Concrete measures can be put as follows:

Measures to contain the extravagant growth of high-energy-consumption and high-emission industries include: modify catalogue of the investment projects for approval by adding the high-energy-consumption and high-emission projects such as coke, calcium carbide and iron alloy projects for approval; amendments to the "catalogue for industrial restructuring"; establish or modify access criteria of high-emission industries such as yellow phosphorus, iron alloy, coking and cement industries, verify and announce the eligible enterprise timely; implement the production license management according to the law, strictly check the high-energy-consumption and high-emission production condition during the process and refuse to issue the license if not meet the requirement; continuously correct the

preferential policies such as electrovalence, land prices and taxes and fees for high-energy-consumption and high-emission industries; implement the new "industrial guiding catalogue for foreign investment" and strictly limit foreign investment in high-energy-consumption and high-emission projects; strictly control the export of "high-energy-consumption, high-pollution and resource-dependence" products continuously; vigorously accelerate the development of the service sector and high-technology industries and enhance their proportion in national economy.

The second is to shut down backward productivity by "keeping and promoting the large and holding or close down the small", which is an important approach for power industry to implement the structure adjustment and achieve the goal of energy saving and emission reduction. It is necessary to stick to it and get it improved in the process of policy innovation. Take the power industry for example, 533 small thermal power plants with a total capacity of 14.38 million kw were shut down in 2007, which was 43 percent more than the target established by the State Council, and 37.6 million tons of CO₂ emission was reduced. Energy saving and emission reduction in power industry play a significant role in reducing energy consumption, achieving gross control objectives of main pollutions during 2006 to 2010 and building a resource-conserving and environment-friendly society.

6.5 Mobilize the whole society to participate in actions of addressing climate change

Intensify the training, publicity and guidance of climate change and take it as an important part of science popularization and enhancement of public scientific literacy. Carry out climate change propaganda and relevant science popularization activities according to the different circumstances of big cities, medium cities and rural areas, and enhance the public knowledge of climate change. Publish the climate change knowledge and the measures taken for coping with it by making full use of a variety of media.

Governments at all levels should enhance the public awareness as an important task for coping with climate change and mobilize the society to participate in coping with climate change; further enhance the climate change awareness of leaders at all levels of governments, enterprises and institutions and gradually build a leading cadres with a high global climate change awareness; also reduce GHG emissions by all sectors of the community; Public participation in climate change activities, including advocacy of no lower than 26 °C for air-conditioning temperatures in public building in summer, China Urban Public Transport Week and Car Free Day activities, and promotion of the use of products with energy-saving identification.

7. Technical Policies for Low Carbon Economy

7.1 Energy technology options

The development and utilization of energy is one of the biggest sources of GHG and other pollutants, also energy is the essential material basis for the social development and human existence. An important problem that confront the whole world commonly and needed to be properly solved is the conflict of energy, environment and development. On one hand, there are limited primary energy such as oil and natural gas and they may exhaust under the background of rapid growth of energy consumption; on the other hand, a large part of GHG emission is produced from burning of traditional fossil fuels, energy technology needed to be more cleaner and more climate-friendly to meet the requirement of coping with climate change.

Advanced energy technologies development for improving energy efficiency and promoting the use of new energy is the root approach to solve the current energy problems and achieve sustainable development. Science and technology are drive and backbone of the human social progress and economic development, which has been demonstrated in each historical stage of human social development and has become the consensus of mankind. Relying on the power of science and technology, we continuously improve our material and cultural life and climb on one and another new development ladder. In order to solve the energy and environmental problems effectively we still need the development of science and technology . In recent years, energy saved through enhancing efficiency is much more than energy from new resources, in addition, it has influential impact on world economy for turning it to resource-saving development. However, the world's energy demand has continued at an annual rate of 3% growth and energy demand will continue to grow even if many kinds of energy-saving policy will be taken in the future. Especially in developing countries, energy consumption will inevitably increase for their social development and fulfilment of industrialization. Therefore, in order to prevent global climate change and protect human living environment, the development of advanced energy technologies should not only be one of the energy strategies in developed countries but also the whole world.

7.2 Suggestions on China's technical policy of GHG emission mitigation

Technology is critical for emission reduction. Based on our research, major suggestions on technical policy making on GHG emission reduction for China are listed as follows:

- 1) Developing advanced and suitable technologies with top-priority: energy saving

and efficiency improvement; new and renewable energy technology; clean coal technology; oil, gas, CMM high-efficiently utilization technology; advanced nuclear technology; CCS; bio-carbon-sequestration and carbon sequestration engineering technologies, LULUCF technology to control GHG emission.

2) Strengthening research on advanced technologies: emphasizing the importance of technical advancement and innovation; strengthening and investing more on climate change related technical organization and coordination; accelerating R&D, demonstration and dissemination of good technologies related to climate change mitigation and adaptation; emphasizing R&D on clean coal technology; emphasizing development and utilization technologies at low cost and scale.

3) Strengthening international technical cooperation and promoting international technology transfer: setting up effective technical cooperation mechanism to promote R&D, utilization and transfer of technologies addressing climate change; eliminating policy, institution, procedure, finance and IPR related barriers existing in technology cooperation, and providing incentives measures for technology cooperation and technology transfer; establishing international technology cooperation fund, in order that Environmental Sound Technologies (EST) are affordable and feasible to developing countries.

4) The development direction of GHG emission controlling technologies should analyze, follow, and foresight beyond current international trends: collecting international market supply information, strengthening oil and gas importing capacity, positioning nuclear and wind power as important substitutional energy, and vigorously developing mature zero-carbon technologies such as nuclear and wind power technologies; positively developing clean coal technologies such as ultra supercritical power generating technology, IGCC, etc. Organize related scientific research, follow and research technology progress in linking and applying CCS in IGCC and NGCC, and discuss possibilities of applying CCS in power, cement, and steel sectors.

8. Incentive-based Market Instruments and Implications for China

8.1 Incentive-based Market Instruments: Policy Design

The policy design is a quite complex matter, not only relies on the economic, technical and social context, but also determined by which criteria the policy maker values the highest. When it comes to climate change, instrument design for each country will be quite different, depending on the country's own characteristics, such as whether it has already some environmental related tax such as consumption tax on energy, or already a mature emission trading market such as sulfur trading regime and etc. So to begin with this section, the question is: what is the appropriate market instrument for abate GHG emissions for China, in particular is it a price based instrument (carbon tax) or a quantity based instrument (cap and trade)?

For policy design, the following principles need to be considered to achieve the environmental target.

- 1) ***Efficiency or Cost-Effective Criteria:*** Ideally, one can compare the benefits and costs of applying various policy options, and chooses the one with maximum net benefits. However, in reality, benefits usually are un-measurable or difficult to calculate, thus a full cost-benefit analysis sometimes is difficult to be implemented. So the government can thereby opt for the second-best option, to exert a goal to begin with in the first place, then choose the one at least costs. Since the sources of climate change in a wide range of countries, or within one country with a wide range of states or provinces, the marginal costs of different mitigation options are heterogeneous, thus leave spaces to bring down total costs by using a variety of cost-effective mitigation options. Ideally in the equilibrium all the mitigation actions or activities achieve the condition that all the marginal costs are equal across firms, states and countries ultimately.
- 2) ***Enforcement and Penalty Design:*** Free-riding is a big problem for the climate change issues. Thereby policy designs on enforcement, in particular penalty mechanisms, should be designed to provide sufficient incentives to prevent carbon leakage and cheating across countries. However, trade sanctions or bans currently discussed the most, such as the US McCain-Lieberman Bill, are not good penalty strategies, which in fact are not “win-win” options but “lose-lose” ones. In practice these may increase the costs of reaching a certain goal, can be very destructive for the economy as a whole.
- 3) ***Political Economy:*** Besides the costs and benefits, other political economy characteristics such as sectoral distributional effects, tax incidences, political feasibility, and interest group influences all play important roles. In terms of climate change, since Kyoto Protocol are interplaying with Montreal protocol, and trade treaties, those issues should be discussed and coordinated for the global agreements as well.

To mitigate future climate crisis, each country needs to consider from its own national perspective to choose effective and efficient policy instruments, in particular whether it should opt for price-based instrument such as national carbon tax, or quantity-based instrument such as emission trading or “cap-and-trade” policy?

For China, we regard carbon tax as more political feasible and superior to a carbon cap and trade system for the following reasons, in particular in the short run.

- Carbon accumulates in the atmosphere over time, thus climate change is essentially a stock pollutant problem. Based on Weitzman’s theory on prices vs. quantities, under uncertainty if marginal cost is relatively steeper than marginal benefit curve, price-based instrument is preferred for less deadweight losses. Newell and Pizer (2003) compared the efficiency of taxes and quantity regulations using numerical models, suggesting that tax instrument dominates quantity regulations, though within their parameter choices preferences shift from tax to

tradable permits in the later periods. With no experiences on tradable permits in China, we think it would take time to learn how to build permit market with time, so in the short-run a carbon tax will be a favored instrument to implement domestically.

- Carbon tax is imposed on production and consumption process, with fixed tax rates and will have substantial effects in both short-run and long-run. In short-run, it discourages the utilization of end-use energy in both production and final demand. In the long-run, it gives firms incentives to invest on technology innovation, diffusion of no-carbon or low carbon technologies, and further reduce CO₂ by choosing a cleaner developing path.
- To China, carbon tax is easier for the government to implement, without building a brand new carbon emission market, while the latter requires time and learning process to build capacity for institutions, market regulations and so forth, and initial transaction costs are expected to be quite high. Thus for many developing countries with low capacity to reduce transaction costs associated with new market, carbon taxes can be implemented much sooner than a complex cap-and-trade system.
- In addition, the carbon tax can be levied at the upstream choke points: refinery input for oil, major pipeline collection points for gas, and mineheads or rail and barge collection points for coal (Cooper, 2008). It is also easy for implementation by levying on imports of fossil fuels or gives a refund on exports for unilateral carbon tax.
- Carbon tax could be a major source for government revenue, so in practice is appealing to the Ministry of Finance in China. Another issue would arise, when we consider the current major fiscal reform in China. Ideally, all the key taxes are under discussion of future reform, such as capital income tax, VAT tax, resource tax and etc. Thus, a carbon tax can be fitted very well with the forthcoming tax reform in China, carbon tax revenue can be used to recycling other more distorted taxes, such as capital tax and VAT taxes in China. A revenue neutral tax reform can not only mitigate climate crisis at the global level, but also improve the efficiency in the Chinese fiscal system. On the other hand, although an auction based cap-and-trade is likely to become a hidden tax, it is politically difficult to implement for both China and other countries.
- Carbon tax is more transparent and easily understandable, thereby more likely to get a broader public support than a complex cap-and-trade system, in particular from the perspective of China when the government information disclosure and public participation is still weak.
- Carbon tax can be implemented with far less opportunity for manipulation by special interest group, while a cap-and-trade system would involve more strategic behaviors, thus may undermine public interests and undercut its effectiveness. For

example, powerful firms can bribe to get more grandfather emission quotas in the first place.

By arguing carbon tax is a favored choice for China, we do not suggest that other countries should also opt for this instrument as well. For example, US has already a mature and complex sulfur trading system, it would be easier for US to opt for emission trading rather than carbon tax. Because of the urgency of the climate crisis, we don't have the luxury of waiting until all the countries have the consistent cap-and-trade system or harmonized global carbon tax regime, so we expect in the future the policy regime would be likely to be a hybrid system, incorporating both tax and cap-and-trade policies to resolve the climate change without lengthy negotiations. We also discuss this in detail in the "climate treaty" and ICP section.

8.2 Effects of Carbon Tax in China

As discussed in the former section, initiating a domestic carbon tax regime is quite plausible for China in the near future, in particular that environmental tax as a whole has already under discussion under the Ministry of Finance. Based on the theory of environmental economics, if a carbon tax policy is implemented in China, the carbon emitters would respond by internalizing externality costs while simultaneously reducing the associated environmental health damage from its energy use.

To assess how a carbon tax could affect the Chinese economy and environmental system, we simulate a unit carbon tax regime in our study. The unit carbon tax rate (US dollar per unit of fuel) is calculated by multiplying the exogenous carbon tax rate tx'' (expressed in US dollar per ton of carbon content), with the carbon content (XU_i) per unit of fuel i . The unit carbon tax is calculated as:

$$tc_i'' = tx'' XU_i \quad (i = \text{coal, oil, gas}) \quad (16)$$

The carbon tax rate per ton of carbon content tx'' is exogenously set in the model. By looking at the historical carbon permit price in the EU market and CDM market, we can see that the carbon price is between the range of 14 -24 euros per ton of carbon in 2007. In this study, we pick 10 \$ and 20\$/tC as our tax rates for simulation. Thus with the carbon tax, the purchaser's price of fuel i is:

$$P_{i,t} = P_{i0,t} + tc_i'' \quad (17)$$

where tc_i'' is the carbon tax per unit of fuel use, and $P_{i0,t}$ is the fuel price before the unit carbon tax tc_i'' is imposed. Both domestic fuels and imported fuels are taxed at the same carbon tax rate.

In addition, the revenue neutral condition is assumed here for the counterfactual simulation of the carbon tax. Therefore, the government revenue is assumed to be the same as the base-case simulation. Imposing a new carbon tax would require the reduction of other distortionary taxes, such as capital income tax, Value Added Tax (VAT), sales tax, etc. For simplicity, it is assumed that all the tax cuts are at the same fraction ξ_t compared to their benchmark rate, therefore the counterfactual tax rates are given by:

$$t_t^k = \xi_t t_{t0}^k, \quad t_t^{VAT} = \xi_t t_{t0}^{VAT}, \quad t_t^S = \xi_t t_{t0}^S, \text{ etc.} \quad (18)$$

where t_t^k is the capital income tax, t_t^{VAT} is the value-added tax, and t_t^S is the sales tax.

The fraction coefficient ξ_t is endogenously determined by setting the government expenditure fixed to the base case government expenditure. Thus the constrained revenue neutrality condition is expressed as:

$$GG(t) = GG_{base}(t) \quad (19)$$

where $GG(t)$ is the quantity index of government purchases. In later sections, the fuel tax simulation and output simulation also adopt the same revenue neutrality condition.

The Model Structure of the CGE Model for China

In this project, we use a Solow recursive CGE model to model our carbon tax simulation. The detailed model description including data sources of the original model, is given in the Ph.D. thesis of Cao (2007). The major characteristics of this integrated model are summarized as follows:

Production: The production technology is a nested Cobb-Douglas production function:

$$QI_{jt} = g(j,t)KD_{jt}^{\alpha_{Kj}}LD_{jt}^{\alpha_{Lj}}TD_{jt}^{\alpha_{Tj}}E_{jt}^{\alpha_{Ej}}M_{jt}^{\alpha_{Mj}} \quad (20)$$

where $g(j,t)$ is the technical progress term that is assumed to have rapid technology progress in the beginning, and then the growth rate decrease, and eventually stabilize at the steady state.

Household: The representative household drives utility from his consumption of commodities, supplies an inelastic supply for labor input in productions, and owns a share of the capital stock; it also receives lump-sum transfers and interests on its public debts. For the recursive property, the representative household makes exogenous savings decisions that are transformed into investment in the subsequent period.

Capital and Investment: The Chinese capital stock is modeled in two parts, the first part is a plan share of capital since some state-owned enterprises might receive favorable investment funds directly from the state budget, and the second part is market capital, the rental price of which is equal to the marginal product of capital input. Both types of capital are evolved with investment accumulation and depreciation.

Pre-existing taxation: The model includes a variety of pre-existing taxes, such as taxes on production, consumption; subsidies in production and consumption; tariffs and subsidies on exports. With a recent tax reform in 1994, the Chinese taxation system has moved to one with a broader tax base, a value-added tax cover all the industrial sectors and commerce, enterprise profits tax, and sales tax⁴.

International Trade: This model assumes imperfect substitution among goods originating from China and those from the rest of the world. Imported demand of goods is derived from a CES aggregation of domestic and imported goods. The current account and government debts are set as exogenous.

Market Clearing: All market prices in the model are endogenous and adjust to clear the market for goods and factors. In addition, the government debt balance, trade balance, and savings-investment balance are combined in order to complete the model. The Walras Law is checked to test the market clearing.

Calibration: To improve the robustness of the model, a critical step after setting up the model is to calibrate parameters in the recursive CGE model so that it can successfully “replicate” the benchmark year 2002 for China.

Figure 13 shows the GDP, CO₂, SO₂ and TSP projected in the base case. Now, by comparing the counterfactual simulation and benchmark simulation, we can evaluate the impacts of a carbon tax of 10\$ and 20\$/tC on the Chinese economy and environment.

Figure 14 and 15 shows the effects of carbon tax on the economy. We can see that in the first year, consumption has a negative shock, but it almost disappeared in the last year simulation. Through recycling with capital tax, VAT tax and other taxes, the effect on investment is positive, thus the net impacts on GDP is actually positive, so we can see that the economic costs of imposing a revenue neutral carbon tax are very small. On the other hand, the benefits from reducing energy use, abating carbon emissions, and cuts on other pollutants are significant.

⁴ For simplicity, in this model all the rest taxes with small revenues are categorized into “sales tax” on commodities.

Figure 13. GDP, CO2, SO2, and TSP projected in the Base Case

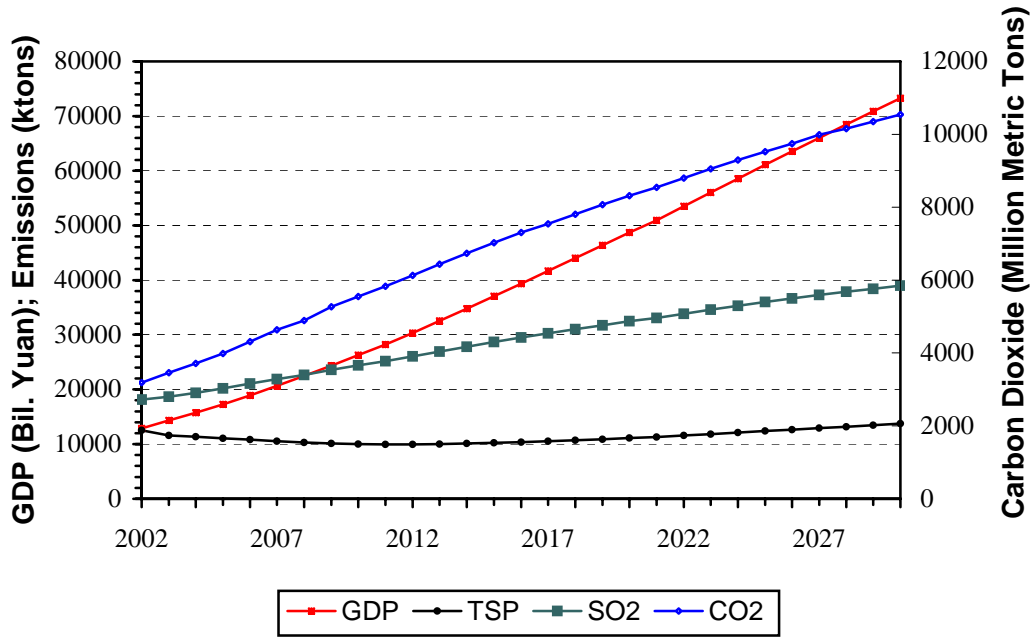


Figure 14. Impact of Carbon Tax (First year)

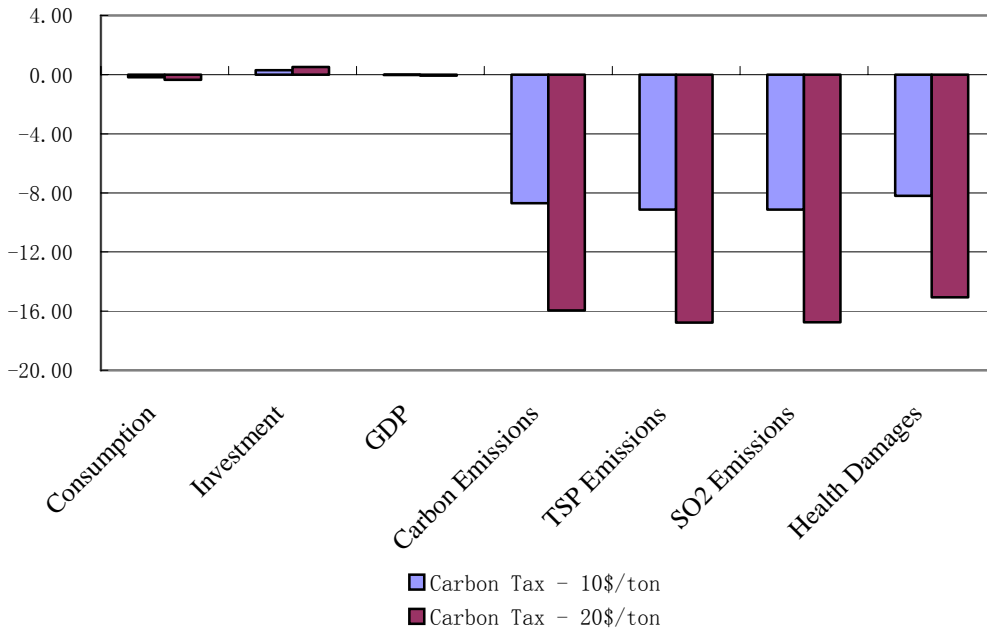
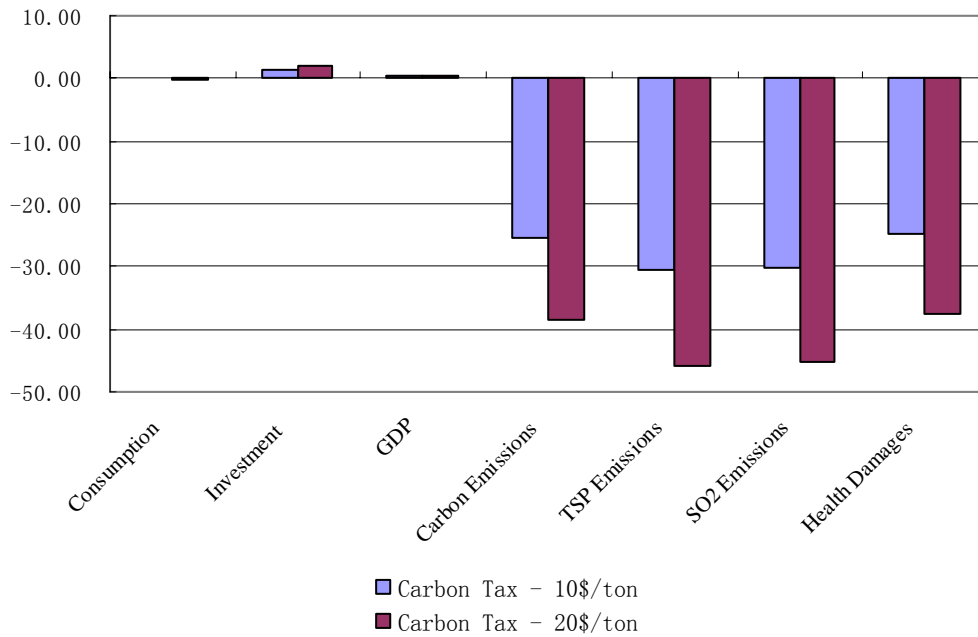


Figure 15. Impact of Carbon Tax (Last year)



8.3 Co-benefits of Carbon Tax Policy

Mitigating carbon emissions through reduction of energy uses, can bring substantial co-benefits from reducing other traditional pollutants, such as TSP and SO₂ emissions, which are major reasons for environmental health damages. Thus besides examining the effects of carbon tax on economy, we also estimate the reduction of associated health damages from the local pollutants. Based on the study by Ho and Nielsen (2007) and Cao et al. (2008), our carbon tax simulation and co-benefits estimateion follows an integrated assessment strategy by following the pollution impact pathway which is outlined as follows.

0. Economic activity and fossil fuel use to pollutant emissions
 1. Emissions to concentrations
 2. Concentrations to human exposures
 3. Exposures to health impact
 4. Valuation of health impacts

The emissions of four pollutants: CO₂, SO₂, TSP and NO_x emissions, are linked to fossil fuel combustion by emission coefficients, for example, tons of TSP per ton of coal. These coefficients are projected to change over time with the use of different control technologies and different production processes. They are industry specific, due to the use of different boilers and control technologies.

Based on the epidemiological studies of health effects, human exposures – how many

people breathe a given amount of each pollutant are estimated, and the “intake fraction” (*iF*) methodology described by Levy and Greco (2007) are applied in this study. The *iF* from a particular source is the fraction of a pollutant emitted that is eventually inhaled by people before it is dissipated. Then we estimate the effects of exposures on health outcomes including premature mortality, chronic bronchitis, asthma attacks, and so on. Finally, the health effects are monetized in order to measure the co-benefits of climate policies. We express the change in the number of cases of chronic bronchitis, premature mortality, and so on, in terms of *yuan*, the Chinese currency. Domestic contingent valuation studies are reviewed to provide unit value for all the health end points.

Based on this co-benefits study, we can see from previous figures (figure 14 and 15) that, in the first year the health damages are reduced between 8-16%, and the effects are even larger with time, and the reduction can be as high as 25-38% in the last year, partly due to the induced technology change when people adjusted to the price signals of the carbon tax policy.

Table 7. Dose-response and valuation estimates in central case.

Health Effect	Dose-response (Cases per mil. per $\mu\text{g}/\text{m}^3$ increase)	Valuation (<i>yuan</i> 2002)
Due to PM		
1 Mortality	1.92	500000
2 Respiratory hospital admissions	12	2500
3 Emergency room visits	235	203
4 Restricted activity days	57500	21
5 Lower resp. infection/child	23	115
6 Asthma attacks	2608	35
7 Chronic bronchitis	61	70000
8 Respiratory symptoms	183000	5
Due to SO ₂		
9 Mortality	1.92	500000
10 Chest discomfort	10000	9
11 Respir. systems/child	5	9

Source: Cao et al. (2008)

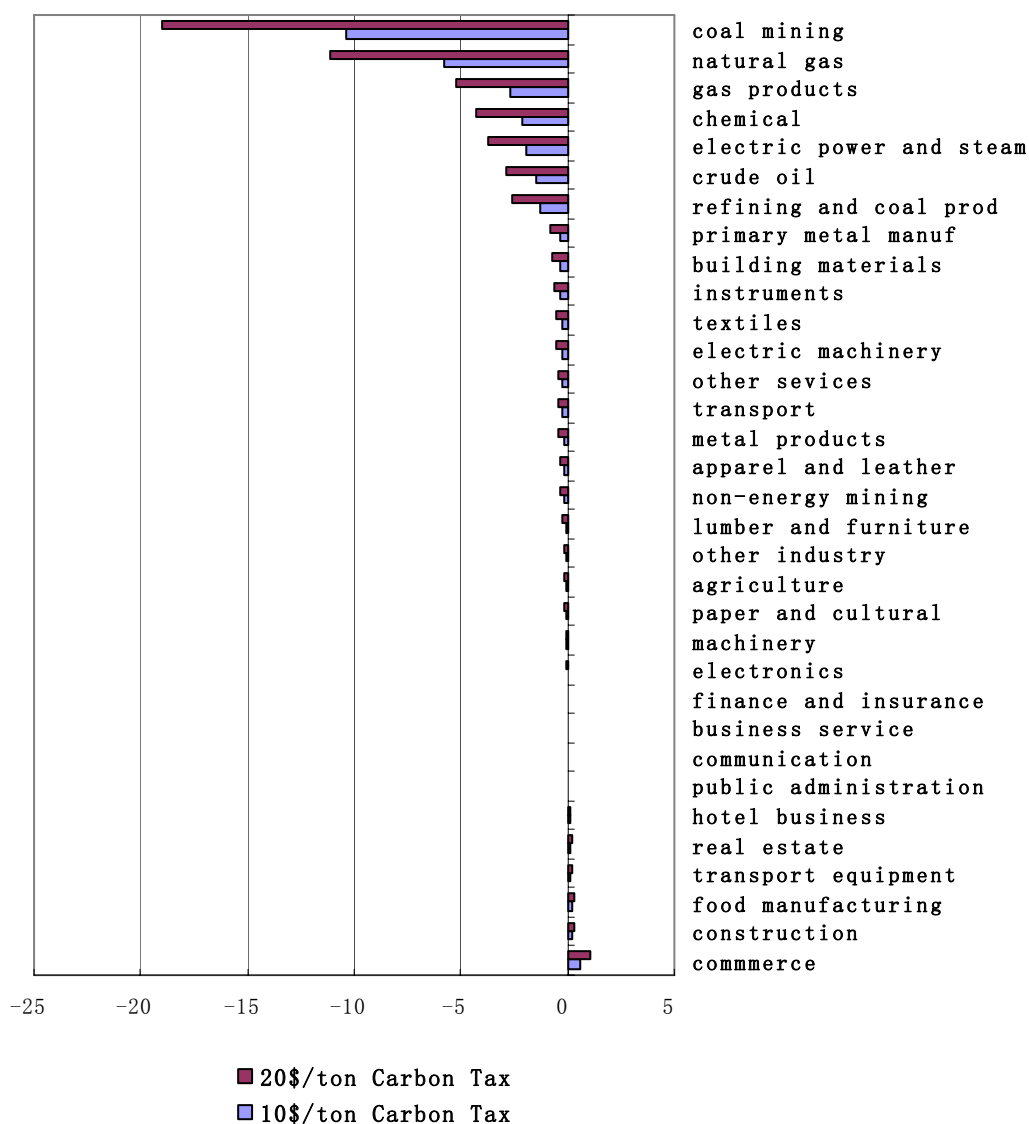
8.4 Distribution Effects

Finally, we examined the distribution effects of carbon tax on different sectors. Figure 16 and 17 suggest that, most energy intensive sectors such as coal mining, electricity are affected the most, output reduced and price increased at the similar magnitude. On the other hand, the relative cleaner sectors such as public administration, commerce and etc, are actually have a positive effects on the output due to the general

equilibrium effects.

Therefore, energy sectors and heavy industry sectors are hit the most under the carbon tax. Competitive issue thus arises, and government may concern their international competitiveness in particular when the same industries in the foreign countries are not subjected to such carbon pricing constraints. Based on the European experiences, one option would be to impose a carbon tax, but refund these sectors subsidies based on their outputs. Thus, this mechanism keeps the momentum for investing on cleaner technologies, while also promoting the incentive to produce more.

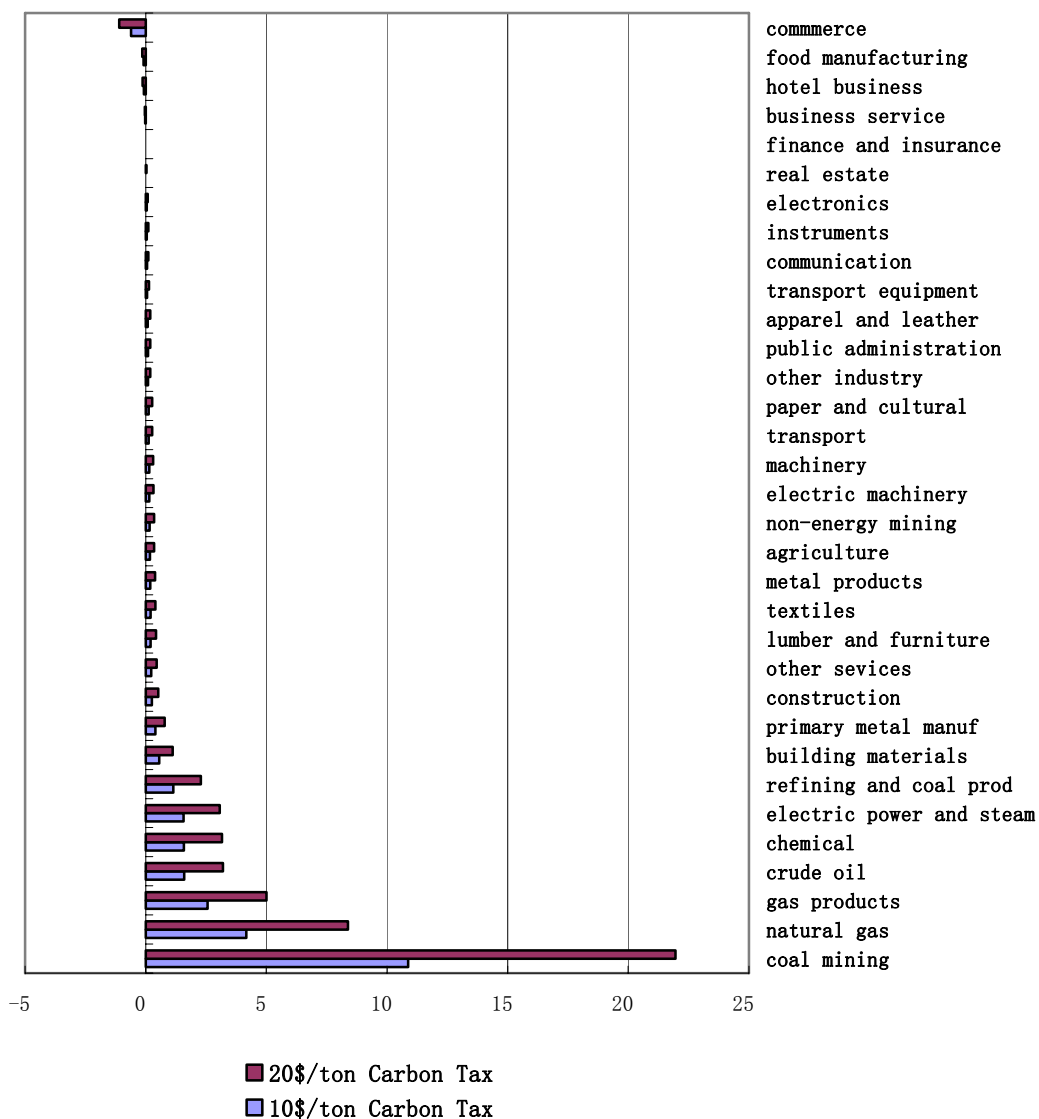
Figure 16. Industry Output Effects of Carbon Tax



The distribution incidence of energy taxes has become a key issue in the policy debate. Most studies show that energy taxes can have a regressive impact on the income distribution of households. However, a full assessment should include the indirect effects from price increases on taxed energy and products, but also effects through revenue recycling and/or compensational measures, and distribution of environmental

benefits resulting from the green tax. The OECD ex-post practices on green taxes, suggest that, many mitigation measures, including exemptions or rate reductions can reduce the environmental effectiveness of the taxes, however more direct measures like compensating low-income households, either through reductions in other taxes or through the social security system, can maintain the price signals of the tax while reducing the negative distribution impacts on the poor, and mitigating the regressivity of the tax instrument (OECD, 2006). Thus, when designing carbon tax for China, in order to assure that distributional concerns are properly addressed, mechanisms on compensating the low-income households should be further analyzed in the first place before real policy implementation, rather than face this question late in the process at a more ad hoc fashion.

Figure 17. Industrial Price Effects of Carbon Tax



8.5 Political Economy Lessons from EU Green Tax Reform

Although a harmonized global carbon tax is an ideal instrument to combat with climate change in theory, given the complications of varying pre-existing taxes and subsidies in different countries, it is very hard for all nations to coordinate and achieve global harmonization (Aldy et al, 2008). However, after about twenty years' green tax reform in the European countries, many ex-post experiences and taxation design lessons can be learned for China for the future carbon tax reform.

Overall, experiences in Europe shows that environmental related taxes can be cost-effective, introducing a price signal that helps polluters to take into accounts the external costs of pollution when making production and consumption decisions. However, two major obstacles exist for implementing environmentally related taxes, namely the fear of loss of sectoral competitiveness and the fear of negative distribution impacts,

Due to concerns on international competitiveness and impacts on tax exemptions and differentiations, energy tax implementation is not imposed at its full scale in EU. For example, some energy-intensive industrial sectors are exempted or not imposed at adequate tax burdens, for example, tax rates are much higher for households than industries, most of the green tax revenue is from petro or motor vehicle related taxes (OECD, 2006). If the existing exemptions and other special provisions were scaled back, the green tax reform in European countries can achieve higher environmental effectiveness and economic efficiency. In the future, when taxes or cap-and-trade instruments for climate change are implemented more in a global manner, in particular if China also adopts carbon tax, then politically it also benefits EU to strengthen their green tax reform for energy-intensive industries. The OECD reports also describe some *ex post* lessons to mitigate the competitive pressures. Countries can design for broadest possible tax base to ensure cost-efficient emission reductions and acceptance from affected parties (OECD, 2006).

The distributional incidence of green tax reform has become a key issue in the policy design debate as well. Most studies show that environmental related taxes, for instance, gasoline tax, can have a regressive impact on the income distribution of households (OECD, 2006). We believe, however that this matter should be studied empirically in a careful manner. It is not obvious that fuel taxes are regressive in developing countries. For instance, Sterner (2008) have shown that, gas tax in South Africa and India are likely to be progressive. Even if in practice, environmental tax can be regressive per se, government can still seek more direct compensation measures through income taxes or social security system, to mitigate the negative distribution effects (OECD, 2006). Actually even for the one with regressive property, mitigation measures can alleviate the negative effects. For example, West and Williams (2004) suggest that, one can easily make the gas tax highly progressive by using the revenue to finance cuts in really regressive taxes. Thus, the tax incidences

are actually an empirical matter and depend fully on the policy design on interactions with other pre-existing taxes or other externalities.

Finally, green tax reform should be applied in combination with other regulatory instrument as well. For the EU and US cap-and-trade system, it has been proved that a hybrid “safety-valve” system is favored by imposing a tax as upper bound of permit price. In some places, to avoid hot spot the tax or permit regime can be also combined with ambient mandates as well. If considering long-run impacts, technology policies such as subsidies on R&D investment should also be considered to avoid infrastructure lock-in and facilitate technological spill over, to complement with the green tax reform. All of these are useful lessons to China to implement a cost-effective carbon tax reform in the near future.

Part III. Meeting global targets through international cooperation

The purpose of this part is to demonstrate how the international cooperation can benefit China's national climate change strategy of which the sustainable development targets are in the center.

9. "Time window"

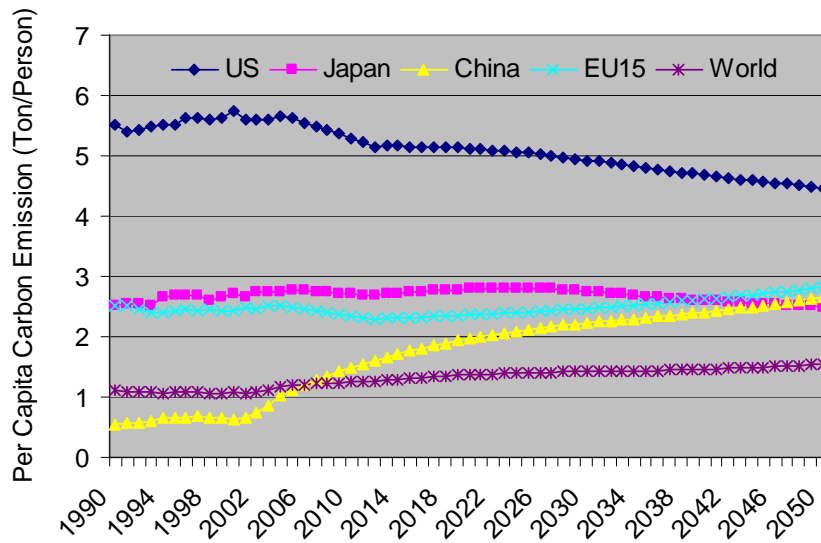
Under the principles of UNFCCC and "Kyoto Protocol", the status of being the largest developing country provides China with a "time window" – in the next decade or a longer period China is not obligated to commit itself to quantified global GHG reduction targets and is entitled for international supports to voluntarily reduce its GHG emission. Within this "time window", China's actions contributing to the global climate change mitigation is centered on reducing the energy and pollution intensities to meet the national needs of development and reduce poverty, like many other developing countries. And these actions are defined in the current global mitigation mechanisms as "non-cap".

On the other hand, in addition to the increasing urgency of climate change and the variation of the mitigation results, this "time window" is primarily affected by following factors and thus has limited amount of time before it is closing (see Fig. 18 and Fig. 19).

- When China's per capita CO₂ emission reaches or is higher than the world average. China was 4.07 ton and the world average was 4.37 in 2005⁵.
- When China's per capita CO₂ emission reaches or is higher than the level of the European Union (EU has set up the target of reducing 20% by 2020 from the level of 1990 when EU-15 per capita emission was 8.1 ton).
- When China's per capita CO₂ emission reaches and is higher than the level of OECD countries (During 1990-2005, China's per capita emission was growing at an annual rate of 7.25% while that rate was 1.01% in OECD countries).
- When China's accumulative emission will reach its population equivalent share of the global stock share, i.e., 21% of the entire stock (see Fig 19).

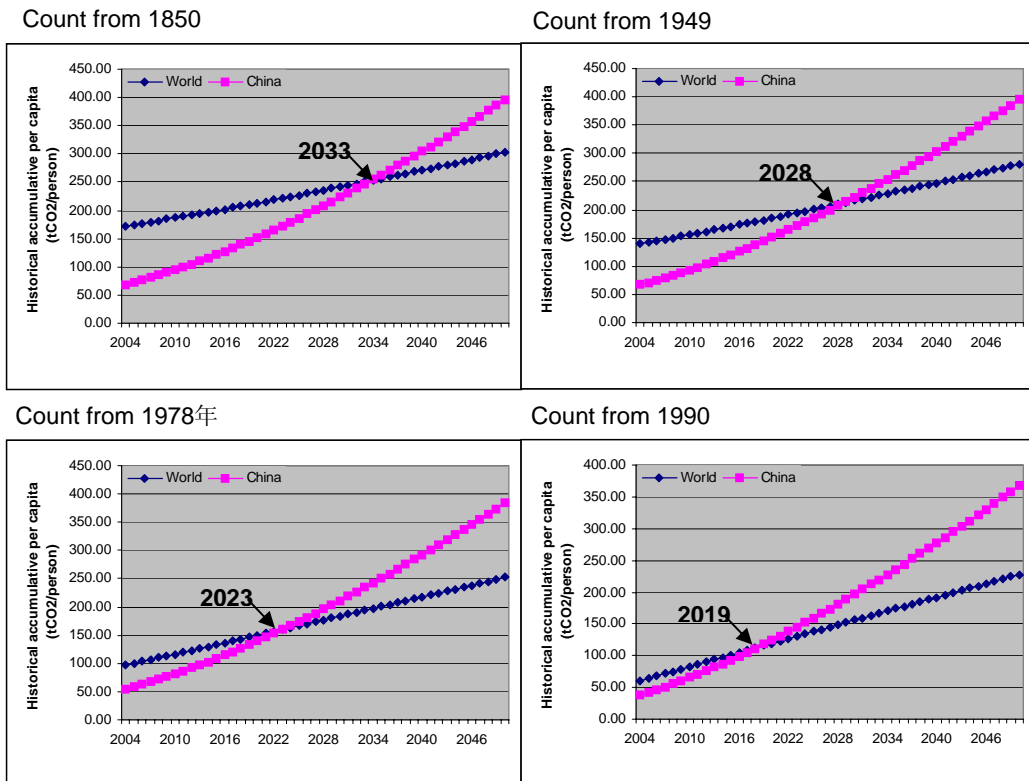
⁵ "World Per Capita Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980-2005" in *International Energy Annual 2005*, posted on October 1 2007, by Energy Information Administration of United States.

Figure 18. Forecast of Per Capita Emission (1990-2050) at Business-as-Usual Scenario



Source of data: WRI, IEA, IFS & WDI.

Figure 19. Crossing Point Forecasted When China's Per Capita Emission Matches its Population Share



Many studies have found that these factors will all be effective quite soon if China's emission increases at 7~8% as it is (see Fig 16). One reason is that EU-15 countries are actively taking strategic shift toward low carbon economies, and their actions have started to show promising results in the last couple of years when climate change was seriously brought up to EU's highly prioritized agenda.

With the "time window", China has the most bargaining power to access the international supports through international cooperation on climate change to benefits from their achievements, particularly advanced technologies, and to promote its national strategy of shifting the pattern of growth in its long-term interests of sustainable development. Through this window, without being "capped" China can effectively link its national energy conservation and pollution reduction plan (FYP 2006-2010) to its national sustainable development targets as contributions to the global mitigation targets, in exchange for technology transfer and financial support. This linkage serves as a foundation of negotiations for China to actively participate in the international cooperation – a global deal, and maximize the international supports to meet the targets of both, which are the largest co-benefits. The inter-country joint mitigation plan (ICP), proposed earlier in this report, is a concrete action plan with specific steps to achieve such co-benefits, and is also a strong "card" of bargaining. ICP will be described further in a later chapter of this part.

Today, the world economy is challenged by the global downturns. This "time window" is particularly important. The Chinese government recently has approved a program of investing 4 trillion RMB to revive the economy. It will lead a new round of infrastructure development. With the opportunity of the "time window" of climate change, China can leverage the international financial support and push its plan of technology transfer from the developed countries, updating technologies and infrastructure to speed up the shift toward a low carbon economy. Through this time window, China can obtain the international supports to help with its economic structural change. China could also lose this opportunity when the "time window" shuts up, i.e. when those factors listed above are all in effects before the actions are taken.

However, in order for China not to lose the opportunity, not only that China needs to take active actions which China has already started taking but more importantly an inclusive, participatory and transparent mechanism for international cooperation is urgently needed. But such mechanism has been so far missing.

10. Problems with current mechanisms – Lessons from CDM Practice

This section gives an analysis of the strengths and weaknesses of the existing mechanisms of international cooperation between developing and developed countries on climate change. The results are linked to the further analysis of costs of "non-cap" for China, which are followed by a proposal of a new, inclusive mechanism as an alternative to materialize the "global deal" of equity, effectiveness and efficiency, and

realize the “additionalities” of emission reduction, technology transfer and finance as defined in the Kyoto Protocol.

Kyoto Protocol has approved three flexibility mechanisms to facilitate climate change mitigation. Clean Development Mechanism (CDM) is the only one so far for Annex 1 (capped) countries and non-Annex 1 (non-capped) countries to take joint actions of emission reduction. It is also a main form of international cooperation on climate change. CDM is designed to have two folds of purpose – a) to assist developing countries (non-Annex I Parties) in making progress towards sustainable development and contributing to the UNFCCC objectives; b) to assist developed countries and economies in transition (Annex I Parties) in achieving their emission reduction targets.

Through CDM, the buyer from developed (Annex 1) countries purchases certified emission reduction credits (CERs) generated from a CDM project in a developing (non-Annex 1) country, taking the advantage of lower cost of emission reduction there. The roles played by two parties in CDM practice are quite different. They are dichotomized in Table 1 by Matthias Krey (2004) ⁶.

Table 8: Roles played in CDM projects

CDM project participants	Form of participation			
	Supplier	Seller	Investor	Buyer
Government, non-Annex I country	X	X	X	
Government, Annex I country			X	X
Company, non-Annex I country	X	X	X	
Company, Annex I country			X	X

According to Kyoto Protocol, CDM projects should generate three “additionalities” – financial, technology transfer and emission reduction. They are taken as a framework of reference for analysis.

Financial additionality: By 10 September 2008, the Chinese DNA has approved about 1550 CDM projects, over 270 of which got registered at international executive board (EB). If all get registered, the estimated annual tCO₂e reduced would total over 325 million, and this amount would make for more than 50% of the world total. Taking

⁶ Matthias Krey, “Transaction Costs of CDM Projects in India – An Empirical Survey”, Hamburgisches Welt-Wirtschafts-Archiv (HWWA) Hamburg Institute of International Economics 2004; ISSN 0179-2253.

EURO€ per tCO₂e as the minimum price line set up some years ago by the Chinese DNA, these projects would make a financial turnover of €2.6 billion. The transaction costs per project range from US\$70,000 to \$110,000 at the pre-operational stage, and the operational phase cost happen only if the projects get registered and start operation.

Up-front (pre-operational) costs:

- Feasibility assessment
- Preparation of the project design documents
- Registration
- Validation and
- Legal work

Operational phase costs:

- Sale of certified emission reductions (CERs)
- Risk mitigation (1-3% of CER value yearly).
- Monitoring & verification (\$3000~\$15000 per year)

Out of the total turnover of EU€2.6 billion, 5~7% go to the up-front transaction cost. The research shows that the smaller is a project scale, the higher is the cost. The transaction costs for small project can go up to 13% while for the large ones the costs run at 1.3%. Then the estimated income brought to China or the project owners totals around €2.4 billion. Tabulated by scale, the Chinese CDM projects are summarized in Table 9.

Table 9: Distribution of CDR projects by scales

Projects by scales (million tCO₂e)	# of projects	%	Estimated annual tCO₂e reduced	%
>10	3	0.19%	31,358,570	9.64%
1-9.99	37	2.38%	93,840,466	28.85%
0.5-0.99	58	3.73%	40,974,773	12.60%
0.1-0.49	599	38.55%	115,151,841	35.41%
0.05-09	402	25.87%	28,929,069	8.90%
<0.05	455	29.28%	14,970,865	4.60%
Total	1554	100%	325,225,583	100%

Data source: China climate change info-net at www.ccchina.gov.cn

As indicated in Table 2, 55% of the projects are small; 29% are below 50000 tCO₂e and 26% in a range of 50000~100000 tCO₂e, or in average a little over 50000 tCO₂e per project. Together they account for 13.5% of the total estimated annual tCO₂e reduced. For these small projects of 7-10 year period, the annual income to the project owners arranges from €15000 to €70000. Medium-sized projects are between 100000 tCO₂e and 500000 tCO₂e, making 38.6% of the total, and could gain an annual income in a range of €150000~200000 in 7 to 10 year period. The large projects of more than 500000tCO₂e make for less than 3% of the total or account for nearly 39%

of estimated tCO2 reduced.

Overall €2.4 billion is not a small financial resource. However, fragmented by many small projects, this resource is much limited. There are medium sized projects; but relative to the scales of project owners, the project scales are not always prominent. If considered together with the demands for technology transfer for the purpose of climate change, the finance generated from these projects would be far from adequate to deal with the issue. For China, the financial additionality of fragmented CDM projects is very moderate.

Technology additionality: A major benefit that should be brought in by CDM is technology transfer to the host or non-Annex-1 countries of CDM projects from Annex-1 countries. Technology transfer is more than hardware supply. By definition, it involves “sharing knowledge and adapting technology to local conditions” (2008, UNDESA), and requires facilitating access to related technical and commercial information and the human skills needed to properly understand it and effectively use it. A critical aspect of the technology transfer process is the development of the domestic capacities to absorb and master the received knowledge, innovate on that knowledge, and commercialize the results⁷. By this standard, the technology additionality is examined.

Table 10. Projects categorized by technologies

Category of projects	# of projects	% of project total	Estimated annual tCO2e reduced	% of total tCO2e reduced
New or renewable energy	1,116	71.81%	131,707,501	39.41%
HFC-23 & N2O	37	2.38%	90,347,035	27.03%
Energy saving & efficiency	267	17.18%	50,221,930	15.03%
Methane recycle	95	6.11%	34,127,861	10.21%
Fuel switch	19	1.22%	13,256,900	3.97%
Other	20	1.29%	14,564,357	4.36%
Total	1,554	100.00%	334,225,583	100.00%

Data source: China climate change info-net at www.ccchina.gov.cn

Table 10 shows that “new or renewable energy” forms a main category of the Chinese CDM projects approved so far, 72% of the total, accounting less than 40% of total estimated tCO2 reduced. The category of “energy saving and energy efficiency” makes for 17% of total number of projects and 15% of the total tCO2e reduced. The

⁷ “Climate Change, Technology Transfer and Intellectual Property Rights”, June 2008, by International Center for Trade and Sustainable Development.

rest are all quite small, except for “HFC-23 & N2O” which account for 27% but have been basically concluded from the CDM practice. Development and deployment of clean technologies, including renewable energy and energy efficiency, have been identified as main solutions to GHG reduction; and they are also the most important driver for the fast growing global carbon market. However, the shares of the clean technologies in the Chinese CDM projects are low in both the number of projects and the amount of CO2 reduction, taking the “category of new or renewable energy” as an example.

Table 11. Projects in the “new or renewable energy category”

Types of new or renewable energy	# of projects	% of total projects	Estimated annual tCO2e reduced	% of total tCO2e reduced
Hydro	803	72.67%	83462645	62.73%
Wind	237	21.45%	27,342,691	22.57%
Bio mass	49	4.43%	9,401,993	7.76%
Power from methane	5	0.45%	238,570	0.20%
Wastes to electricity	8	0.72%	936,230	0.49%
Solar stove	3	0.27%	107,461	0.09%
Total	1105	100.00%	121,151,000	100.00%

Data source: China climate change info-net at www.ccchina.gov.cn

In the category of “new or renewable energy” (Table 4), hydro power including bundled micro hydro projects make for nearly 73% of the total projects or 63% of the total tCO2e to be reduced. Wind power is the next making for 22%, but it is primarily used as the source of CERs rather than aiming to obtain key technologies (Tian & Li, 2008). The projects associated with other advanced technologies in China’s need and also carrying major GHG emission reduction co-benefits, e.g. biomass and solar power, are extremely low in numbers and particularly in sizes measured by amount of CO2 reduced.

The Policy Research Center of Environment and Economics, in 2008 Ministry of Environment Protection conducted a PDD survey of the 202 CDM projects registered at EB. The survey shows that 1/3 of the project documents contain the technology transfer description, 2/3 of which are equipment import at commercial prices without significant “international cooperation” defined by UNFCCC or “Kyoto Protocol”, and rest is about training of equipment operation (Tian & Li)⁸. Because these project documents have no clear definition of “technology transfer”, in practice it allows some technology owners to continue holding the key technologies of equipment that has already been sold.

⁸田春秀, 李丽平, “中国 CDM 项目实施技术转让的政策研究”, 环境保护部环境与经济政策研究中心, 2008

Table 12 shows that majority of “buyers” are European carbon trading companies or carbon funds (67%), followed by banks and institutions (18%). As an important driver of carbon markets, they practice a common business model, purchasing certified emission reductions (CERs) at low prices USD\$10 (€8) through primary transactions of CDM and sell them at higher prices of US\$14.30~19.50 (€11-15) at the European-dominated secondary CDM markets or at European emission trading markets (EU ETS) when imports are allowed⁹. It is not surprising that they are interested in the price of CERs only not in technology transfer. In parallel, many Chinese project owners show the same interests, in earning financial income from the projects rather than new technologies. In other words, the demand for technology transfer is also low. The reasons for the low level of technology transfer in CDM practice will be analyzed further.

Table 12: Distribution of CDR projects by “buyers”

CDM buyers	Estimated annual tCO₂e reduced	%
Carbon funds, dealers or traders	218,170,545	67.08%
Banks or financial institutions	58,344,639	17.94%
Energy or power companies	44,744,010	13.76%
One-side projects	2,902,295	0.89%
Governments	1,064,094	0.33%
Total	325,225,583	100%

Data source: China climate change info-net at www.ccchina.gov.cn

Emission reduction additionality needs to be considered from both project owners and the “destination” of CERs sold. Monitoring the emission reduction of CDM projects is a complicated process particularly when the transactions are imported to the “allowance based” carbon markets. CDM projects generate emission credits which are purchased and then sold in the carbon market based on “allowance transactions”. The credits give the “buyers” permits to emit. How to monitor and verify that the reduction has really happened rather than has been shifted to different locations from rich countries to poor ones – carbon leakage – has long been an unsolved problem. This issue will be dealt with in a special study.

Measured against the three additionalities, none of them has been well met. Technology transfer level has been very low and financial benefits are moderate. If looked at from the country’s needs to cope with climate change, the CDM practice is even further from being adequate. Because to meet such needs requires updating or re-development of infrastructure in a large scale, and phasing-out and phasing-in technologies to drive the structural change of economy. This is far beyond what individual CDM projects can cope with.

⁹ Karan Capoor, “State and Trends of the Carbon Market 2007”, Sustainable Development Operations, World Bank; Philippe Ambrosi, Development Economics Research Group, World Bank, May 2007.

CDM projects have been small in scales as one-time trading, operated at project level and company level, and are traded primarily through dealers at the low-end prices. They are approved without technology transfer mandates at both DNA and EB levels. Procedures are complicated, process is long, and the transaction cost is high.

11. Costs of “non-cap”

While “enjoying” its “non Annex 1” country status, China like many other developing countries is also largely excluded from the global carbon market. The reason is that they are not committed to the global quantified emission reduction targets, i.e. emission cap. The results of the case study of CDM practice are taken to further analyze the costs of “non-cap”. These costs are for both China and the global efforts at emission reduction.

11.1 Costs resulted from the gap between “cap” and “non-cap”:

Kyoto Protocol approved the use of three “flexibility mechanisms” for facilitating the achievement of GHG emission reduction targets. These are: (a) Quantified Emission Limitation and Reduction Obligations (QUELRO) trading for Annex I parties, where countries that emit less assigned amounts of GHG units than they are allowed can sell surplus to those countries that have surpassed their allowances. (b) Joint Implementation (JI), that allows trading of emission reduction units between Annex I parties (developed countries and economies in transition). (c) The Clean Development Mechanism (CDM) involves investment by developed countries in carbon offset projects in developing countries to serve two folds of purpose, mentioned in the previous chapter.

In May 2008, in his “the key elements of a global deal on climate change”, Nick Stern proposes “a liquid international carbon market in order to allow for the most effective, efficient, and equitable emissions reductions”, featuring “cap and trade”¹⁰. Without the participation of developing countries, this global carbon market will not be “liquid”. Therefore, “cap” has to be re-defined under the principle of UNFCCC.

In practice there are three types of carbon markets in operation. EU Emission Trading Scheme (EU ETS) is a dominating market – the sale and re-sale of European Union Allowances (EUAs). Project-based trading is primarily through the Clean Development Mechanism (CDM) and Joint Implementation (JI). The voluntary market for reductions is characterized by transactions among corporations and individuals, of which Chicago Climate Exchange is an example.

CDM is marginal in the context of the global carbon market which has been increasing in a dramatic magnitude since 2005 to 2007 (Table 6). The most active and largest carbon market is EU ETS, having led the market share over 78% since 2005.

¹⁰ Stern N. “Key Elements of a Global Deal on Climate Change R”, the London School of Economics and Political Science (LSE), April 30, 2008.

In 2006 the total trading volume reached a value of US\$24.4 billion (€19 billion), increased from \$8 billion in 2005. This figure doubled, having gone up to US\$50 billion in 2007 (Capoor & Ambrosi, 2007 & 2008)¹¹.

Table 13. Carbon Market at a Glance, Volumes & Values in 2005-06

	2005		2006	
	Volume	Value	Volume	Value
	(MtCO₂e)	(MUS\$)	(MtCO₂e)	(MUS\$)
	Allowances			
EU ETS	321	7,908	1,101	24,357
New South Wales	6	59	20	225
Chicago Climate Exchange	1	3	10	38
UK-ETS	0	1	Na	Na
Sub total	328	7,971	1,131	24,620
	Project-based transactions			
Primary CDM	341	2,417	450	4,813
Secondary CDM	10	221	25	444
Ji	11	68	16	141
Other compliance	20	187	17	79
Sub total	382	2,894	508	5,477
TOTAL	710	10,864	1,639	30,098

Source: “State and Trends of the Carbon Market 2007” & “State and Trend of the carbon market 2008”, Capoor & Ambrosi, 2007 & 2008.

To the global market, developing countries supplied nearly 537 MtCO₂e of primary CDM credits in 2006 for a total market value of US\$5.8 billion, of which China has a dominant market-share making for 61%. In 2007, the amount increased to 551 MtCO₂e in the primary market, while the major increase happened in the secondary CDM market with CERs up to 240 MtCO₂e increased from 25 MtCO₂e in 2006 and total market value up to US\$5.4 billion increased from US\$0.44 billion in the previous year. However, in the global picture, CDM is marginal. The primary CDM makes for nearly 19% of the total; primary and secondary together account for 20% in 2006. In 2007 the share of the primary CDM market dropped to less than 12% while that of the secondary market went up to 8.5%.

Price wise, CDM averaged US\$10.90 per tCO₂e for CERs (€8.40) in 2006,

¹¹ “State and Trends of the Carbon Market 2008”, Karan Capoor, Sustainable Development Operations, World Bank; Philippe Ambrosi, Development Economics Research Group, World Bank, 2008.

representing a 52% increase over the level of 2005 when China started its first CDM project. The vast majority of transactions are in the range of US\$8-14 or €6-11. Although price at the secondary CDM market is higher, the transactions are made by the “buyers” from the primary market, no longer involving the original CDM project owners or host countries.

Active but exclusive EU ETS: The prices in EU ETS are much higher despite the volatility. The average price ranged from US\$24.70 or €19 in 2005 to US\$22.10 or €7 in the EU ETS phase I (2005-2007). Entering into Phase II in 2008, the European Commission is expected to tighten the overall compliance caps allowed to each Member State, and as a result the carbon price tends to go up. This has been one of the biggest determinants of pricing in the Phase II market. In addition, several analyses have shown that there are unmet demands for GHG emission to various degrees, and consequently the price of carbon dioxide equivalent (CO₂e) will rise compared to that of Phase I period. According to the analysis made by Deutsche Bank in June 2008, EU ETS Phase II carbon price should be higher than €35 per ton (see Table 14).

Table 14. Analysts' expectations for EU ETS (Phase II & III)

Company	Projections for Phase II				Projections for Phase III (20% target)			
	Overall shortfall (MtCO ₂ e)	CDM/JI (MtCO ₂ e)	Internal abatement (MtCO ₂ e)	Price (€)	Overall shortfall (MtCO ₂ e)	CDM/JI (MtCO ₂ e)	Internal abatement (MtCO ₂ e)	Price (€)
Deutsche Bank	95	20	75	<35	235	160	75	
Fortis	150	114	36	<48	480	104	377	<48
Societe Generale	305	240	65	<27	500	25	475	<35
UBS	200	108	92		440	108	332	

Source: Capoor & Ambrosi, 2008.

According to Capoor & Ambrosi (2008), the demand for carbon credits by industrialized countries could exceed 2.4 billion metric tons over the 2008-2012 period, whereas supply is estimated at only 1.83 billion metric tons, suggesting a shortfall of close to 600 million metric tons. This estimate is up from a predicted 300 million ton shortfall predicted by the World Bank just one year ago.

There are two types of carbon transactions (see Box 1) situated at the two ends of the carbon market spectrum, project-based CDR at the lower end characterized by low price and small scale and EU ETS at higher end featuring higher price traded in a large scale. A key divider between the two is the “cap-and-trade”. Without “cap”, there will be no “scarcity”; without scarcity there will no good price. CDM is a non-capped market and trading naturally happens at the lower end.

Box 1: Two types of carbon markets:

- Allowance-based transactions, in which the buyer purchases emission allowances created and allocated (or auctioned) by regulators under cap-and-trade regimes, such as EUAs under the EU ETS. The schemes combine environmental performance (defined by the actual level of caps set) and flexibility for mandated participants to meet compliance requirements at the lowest possible cost;
- Project-based transactions, in which the buyer purchases emission credits from a project that can verifiably demonstrate GHG emission reductions compared with what would have happened otherwise. The most notable examples of such activities are under the CDM and the JI mechanisms of the Kyoto Protocol, generating CERs and ERUs respectively.

(source: Capoor& Ambrosi, 2007)

Carbon cap-and-trade regimes allow for the import of credits from project-based transactions for compliance purposes. But EU has always put limit on the import of credits from CDM, because the process of the “import” is perceived containing risks, such as regulation, project development and performance, and can involve significantly higher transaction costs. Even if it happens, the process is exclusive without engaging CDM host countries or project owners. The EC Draft Directive proposed on January 23 will likely put the restriction to the imports of CDR credits generated post-2012 as long as an international agreement is not reached. This is another factor driving the carbon price at EU ETS higher. The reason for this is quite simple: CDM project host countries do not take “emission cap” i.e. quantified emission reduction targets.

Redefinition of “cap-trade” is needed to engage developing countries into the global deal from the beginning and throughout the deal. If the world pays an appropriate attention to what China has been doing, it is not difficult to see that China has already voluntarily taken radical steps “capping” its emission in a strong magnitude and an impressive scale. However, the current mitigation mechanisms are not acknowledging the initiative as such. This will not only affect the implementation of China’s energy conservation and pollution reduction plan, but also affect meeting the global mitigation targets.

Theoretically “cap and trade” is a market incentive. Under the principle of UNFCCC “cap” should be attached with more accurate definitions. Firstly, it has to be acknowledged that the targets of the sustainable development should be put in the heart of the climate change mitigation plan of the developing countries. Secondly, it has to be acknowledged that the emission reduction plan of developing countries for a certain period of time has to be intensity-based, i.e. reducing energy or carbon intensity rather than reducing the absolute amount of CO₂.

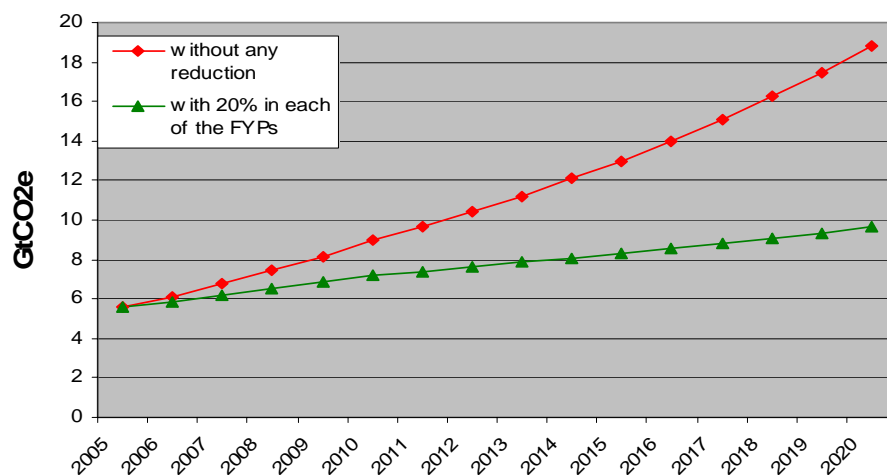
In fact, reducing “intensity” will lead to the reduction of the absolute amount. Take China as an example. If China continues its “5-year plan” of reducing energy intensity by 20% and pollution intensity by 10% for two more periods, it is very likely China’s GHG emission will be peaked sooner or later. Participation in the global carbon market will facilitate this process. But on the contrary China is excluded from this market, according to this exclusive definition of “cap”.

11.2 Costs resulted from recognizing no voluntary national “cap”

There are two basic facts taken as preconditions for this analysis. Firstly energy saving results in GHG reduction, as about 80% of cumulative CO₂ stock comes from burning of fossil fuels, and therefore an energy saving plan is equal to a GHG reduction plan. Secondly China’s emission reduction at present stage has to be “intensity based” for next decade or so under the principles of UNFCCC.

It is world known that China has adopted the quantified targets of reducing energy intensity by 20% and pollution (SO₂ and COD) intensity by 10% in its 11th 5-year plan period (2006-2010). Reduction of energy intensity by 20% means a little over 21% reduction of carbon intensity. If this target is operational for three 5-year plan periods in row with success given GDP growth at 10.04% during the 11th 5-year plan, and 7.67% in both 12th and 13th 5-year plan periods (Jiang, 2008)¹², by 2020 China would accumulatively have avoided 58.1 GtCO₂ (see Fig. 20), which is a great contribution to the global climate change mitigation. In financial terms, taken the carbon price of €40 per ton estimated by the Deutsche Bank in June 2008, the total cost of reduction would be €32 billion, without using the true carbon price of USD\$180 per ton. In a vision of such, China is taking a very ambitious and aggressive “cap”.

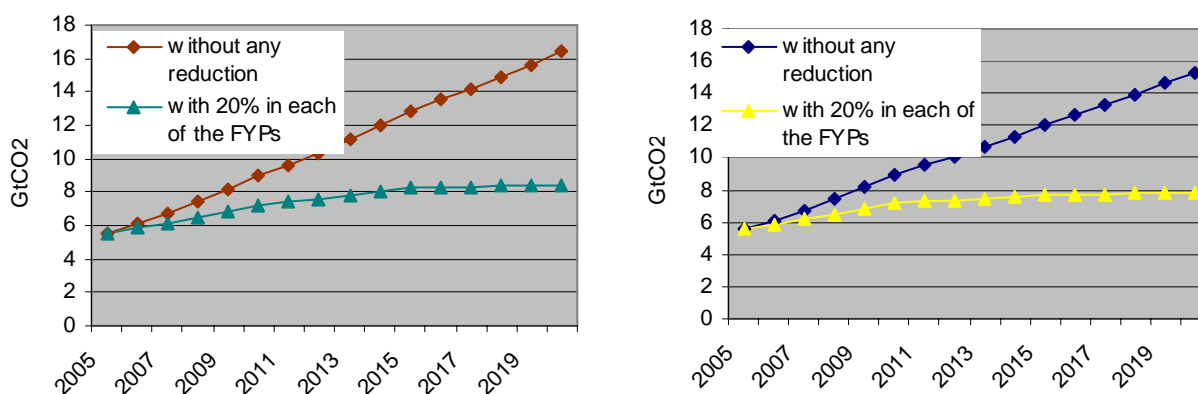
Figure 20. Forecasting CO₂ reduction in three Five-Year Plan Periods



¹² Jiang Kejun, “energy and emission scenario up to 2050 for China” (2008).

If GDP grows at 10% during the 11th 5-year plan, 7.5% during the 12th 5-year plan and 5% during the 13th 5-year plan, the total accumulative carbon avoided would be 54.8 billion tCO₂e and China's carbon emission would be peaked then (Fig. 21, left panel), and the peak time is even earlier if GDP growths is at 10% during 2006-2010, at 6% during 2011-2015, and at 5% 2016-2020 (Fig. 21, right panel).

Figure 21. Forecasting GDP growth and carbon emissions



The questions are “Can China afford by itself the two more 5-year plans with the same energy saving and emission reduction targets?” Can China benefit from the international cooperation on implementation of these plans?

To answer these questions, it is needed to look at how China is doing with the current 5-year plan targets. According to the Mid-term Evaluation of Implementation of Energy Conservation and Emission Reduction during the 11th 5-Year Plan Period, conducted by the Development Research Center of the State Council, the anticipated targets have not been met although great progress has been achieved (see Table 8). To achieve the quantified targets, by June 2008 China has shut down or suspended small-scale thermal generating units of 25.87 million Kw, and closed the production of cements by 100 million tons, steel by 50 million tons, coke 30 million tons and paper totaling 5 million tons in 2.5 years. In these actions, the Chinese Central Government invested RMB ¥21.3 billion in 2006, RMB ¥23.5 billion in 2007 and RMB ¥27 billion in 2008 (DRC, 2008)¹³. In addition, a series of policy instruments have been employed. The resource tax and the consumption tax for high emission vehicles have been increased; export rebate on energy intensive and polluting products haven reduced; and punitive duties have been levied; the electricity price policies have been adopted to encourage desulphurization by power plants and consumption of electricity produced through renewable energy, etc.

¹³ “Mid-term evaluation on implementation of energy conservation and emission reduction during the 11th 5-year plan period”, November 2008, study conducted by the Industrial Economics Research Department, Development Research Center of the State Council of the PRC.

Table 15. Progress of the 11th 5-year Plan Targets

	The 10 th 5-year plan period			The “11 th 5-year plan” period			
	2000	2005	Change	2006	2007	Jan-June 2008	Targets met
Energy consumption per unit GDP (constant price in 2005)	1.19	1.22	2.52%	-1.79%	-3.66%	-2.88%	34% of the anticipated targets
SO2 emission (unit: 10,000 ton)	1995	2549	27.77%	-1.54%	-4.66%	-3.96%	51% of the anticipated targets
COD (Unit: 10,000 ton)	1445	1414.2	-2.13%	0.98%	-3.14%	-2.48%	35% of the anticipated targets

Source: DRC, 2008.

The technological solutions have been largely put in place, playing a major role in meeting the targets. However, at the same time, the two sectors – construction and transportations – are not only energy intensive but also are experiencing rapid growth, making the negative contribution to achieving the targets. This has left the rest of the targets even more difficult to meet, requiring the structural change of energy mix, major technology progress and change of the economic structure. Project-based CDM will not be able at all to help with the reduction in such a large scale.

Meanwhile, to meet the targets China launched the “top 1000 enterprises energy conservation action plan, with a total energy consumption reduction target of 100 million tCE in 5 years. The CEO of each participating company has signed energy conservation agreement with the Chinese government. A strict penalty is applied to the failures. By the time of completing this plan, the government will have invested RMB ¥25 billion, awarding ¥250 for each tce of energy consumption reduced, not including implementation and administrative costs; the spending of RMB ¥5.56 billion was made in 2007. At the same time, 27 provinces have established specific funds for local implementation, and RMB ¥3 billion were already invested. The spending on technology updates and refurbishing already amounted to 50 billion in the same year (Yu Cong, 2008)¹⁴.

CDM projects practiced in China can not help at all with these major actions while the global carbon market with major financial flows excludes not only China but all the “non-capped” countries with the major voluntary quantified emission reduction targets defined in their respective national plans. Considering the urgency of the climate change issue and the huge costs involved in mitigation, the current “flexibility mechanisms” situated at the two ends can hardly meet the increasing demands in the

¹⁴ YU Cong, “Top-1000 Enterprises Energy Conservation Action Plan”, presented at the 11th Senior Policy Advisory Council Meeting, 14 November 2008.

middle – the voluntary intensity-based quantified emission reduction targets set up by the developing countries as part of their development plans. Then the worse scenario is that China has to relax its national “cap” because they can not afford the costs of reduction or are blocked by the insufficient technology capacity.

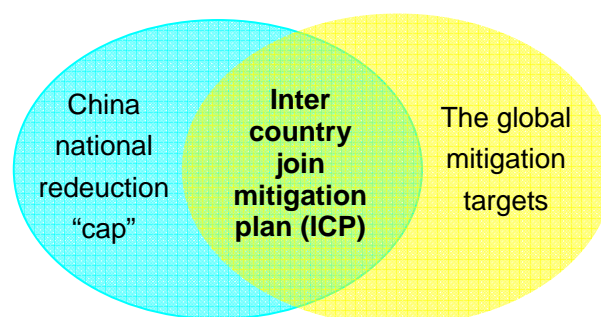
In summary, the current definition of “cap and trade” needs to be redefined to accommodate the national initiatives of developing countries. The mitigation mechanisms based on the divider between “project-based” and “allowance-based” transactions more hinders than facilitates meeting the global targets. A middle-ground mechanism for the full participation of developing countries and developed countries is needed and has to be established urgently to make the “global deal on climate change” work.

12. Designing an inclusive middle-ground mechanism for effective international cooperation – ICP

This new inclusive middle-ground mechanism is called Inter-Country Joint Mitigation Plan (ICP). ICP is not outside but under the principle of UNFCCC, and is underwritten by the principles of equity, effectiveness and efficiency¹⁵. It is also inclusive, transparent and participatory, engaging the developing countries from the beginning and throughout the process.

ICP has two principles as its preconditions. The first one is the principle of UNFCCC – “common but differentiated responsibilities”. Secondly, the national climate change mitigation plans of developing countries are voluntary without global capping, are intensity-based and continue serving the two folds of CDM purpose but in a much larger scale: a) to assist developing countries (non-Annex I Parties) in making progress towards sustainable development and contributing to the FCCC’s objectives; b) to assist developed countries and economies in transition (Annex I Parties) in achieving their emission reduction targets.

Figure 22. Structure Representation of ICP



ICP is a comprehensive plan, incorporating technology transfer, financial flow and

¹⁵ Stern N. “Key Elements of a Global Deal on Climate Change R”, the London School of Economics and Political Science (LSE), April 30, 2008.

emission reduction. It is still formed under the principles of UNFCCC, putting the sustainable development in the center. ICP is agreed at the government level, consisting of host country (non-Annex 1) and a partner country or countries (Annex 1). The private companies can join the plan but it is no longer a deal between the companies as CDM has often been.

Equity: ICP is formed by a host country (developing country) and one or more partner countries (developed countries). The host country proposes a voluntary, intensity-based emission reduction plan with quantified targets based on the country's sustainable development goals, and invites the partner countries to join. China's 20% energy intensity reduction and 10% pollution intensity reduction can be a proposal of such. The proposal also contains the financial resources and technologies required to meet the targets. Through negotiations, the host country and the partner countries reach an agreement, which among others specifies the responsibilities, obligations and rights taken by each party in the respects of financial obligations and technology inputs and the carbon credits gained. The agreement of ICP is signed at the country level, and becomes effective upon the approval of the designated international executive body under UNFCCC, which should be established, similar to the CDM international executive board (EB). Monitored transparently against the international standards, the results of emission reduction, technology transfers and financial flows all are measurable, reportable and verifiable. At the end of the day the emission reduction results count toward the emission targets of the partner countries according to their respective contributions and commitments bind by ICP. The surplus can be sold in the global carbon market.

Effectiveness: ICP learns from the best practices of the partner countries, making use of both policy instruments and market mechanism and also draws the experiences and lessons from the Chinese practice. It establishes energy statistics, baselines, reporting and verification systems. Key indicators are created to monitor and evaluate the mitigation process and results. International standards are applied in monitoring and evaluation process, supervised by the designated international executive body under UNFCCC. Although the international verification process may raise the cost and make the tasks more challenging to the host country, the same standards are applied to measure and verify the technology transfer and financial support provided by the partner countries. As a result, the international supports both financially and technologically will offset these costs and benefit the host country in a greater deal.

ICP is large in scale, and can effectively take the sector-based or province-based approach, meeting the large demands of phasing-in and phasing-out of technologies and infrastructures, to avoid "lock-in" effects and support the structural change of the economy toward low carbon. ICP should be taken not only seriously but also urgently, in order for China to take the unique opportunity of the "time window".

The results of ICP should be reported at COP.

Efficiency: ICP is a win-win solution to effectively reduce GHG emission without slowing down the economic development of the host country. For the host country

ICP is no longer transactions at low-end prices. Take China's energy conservation and emission reduction plan for example. ICP links this national plan to the global emission targets, with it China take an active part in the global carbon market, exchanging for advanced technologies and financial support. For the partner countries, the lower cost of emission reduction in the host country will help them meet their emission targets more effectively. The high transaction costs and risks of carbon "leakage" involved in importing CERs for the compliance purpose are replaced.

When this report is written, the Chinese government has approved a 4 trillion RMB program to stimulate economy. This will lead to a new round of development of infrastructure. Once in place, the infrastructure will easily last half a century. Taking the opportunity provided by the "time window" of climate change, China introduces new technologies and attracts the international investment through ICP to low its climate change mitigation costs.

As said above, ICP is a comprehensive voluntary intensity-based national emission reduction plan, linked to the global mitigation targets. It is a plan, involving major financial flows. Where does the financial resource come from to finance ICP? The answer is explored in Modified-GDR approach.

13. Structure of financial resources in R-GDR approach

According to the estimate in *Stern Review*, an upper bound for the expected annual cost of emissions reductions consistent with a trajectory leading to stabilization at 550ppm CO₂e is likely to be around 1% of GDP by 2050. Taking the data of 2005 as an analysis entrance, 1% of the world GDP is USD\$439.08 billion (in current price). Where does the money come from?

13.1 Sources of funds

Such large financial resources can only be built on the public-private partnership (PPP) basis. The public funds take the lead to leverage and provide incentives for the private investment. Coming to the implementation of ICP, the PPP based investment has three sources.

The first is the multilateral funds (MF), which are primarily contributed through the public finance of developed countries and by large private corporations. Supervised by the UNFCCC authority body, MF is managed and operated by international professional (financial) agency. It is similar to the three special funds under UNFCCC operated by GEF, including Special Climate Change Fund (SCCF), the Least Developed Country Fund (LDCF) and Adaptation Fund (AF). Unfortunately, these funds are very small. For example, to SCCF donors had committed USD\$60 million by November 2006.

MF plays a critical role in ICP. It can effectively leverage the public finances from both the host country and partner countries, and attract the investment from the

private sector. In its international capacity and credibility, it leads the expansion of technology markets, shares and lowers the cost of technology transfer and deployment, and also leads the financing based on public and private partnership. It has also been proved that MF is very good at supporting innovation, pilot programs and capacity building. In July 2008, Climate Investment Fund (CIF) was approved by the Board of Directors of the World Bank, to contribute to demonstration, deployment, and transfer of low-carbon technologies and to pilot new development approaches or scale-up activities aimed at a specific climate change challenge or sectoral response through targeted programs. This fund meets the ICP demands perfectly.

The second source is the public finance of the ICP participating countries – host and partners. The contribution is made according to the commitment and responsibilities agreed upon. The purpose is to support fulfilling these responsibilities and commitments. For example, the Chinese government investment in the top 1000 enterprises energy conservation plan is a form of such. The funds from the partner countries can support the technology transfer and cooperation process among other activities. The public finance has strong policy implications and plays an important role of leveraging and providing incentives for the private investment. It leads the structural change of economy, by facilitating the markets for low-carbon technologies to avoid “lock-in” impacts.

The third one is the private or business sector is the main source of investment. At the same time, most of the technologies coping with climate change are owned by the private sector. The 1000 Chinese enterprises participating in the energy conservation action plan have invested 50 billion RMB in the technology reform and updating. China has a large technology market and great space for improving its energy efficiency, attractive to the private investment. MFs and public finance combined with policy instruments are not only incentives but also effective in leading and facilitating the market and lowering risks for the private sector. When both are in effects, it is the private investment that eventually will scale up the actions and economy through market.

13.2 Financial responsibilities in M-GDR approach

Except for a couple of Scandinavia countries or a little more, very few developed countries have materialized their commitments to 0.7% of their respective GDP to helping the developing countries cope with climate change. If we look at these commitments together with the total annual costs of mitigation, the responsibility and capacity index (RCI) in the Modified GDR approach (M-GDR), provides a guideline to identify the financial responsibilities.

Using the world GDP of 2005 as a case, the annual mitigation cost totals USD\$439.08 billion (in current price). Then consumption based RCIs in monetary term for some main countries are displayed in the table 16.

Table 16. Consumption-based GDRs Allocations and Relative Share in Local GDP

Country	RCI in R-GDR	RCI in monetary terms (billion USD)	RCI in GDP (%)
USA	37.4	\$164.22	1.32%
Japan	7.8	\$34.25	0.73%
Germany	7.5	\$32.93	1.18%
UK	6.9	\$30.30	1.38%
France	5.1	\$22.39	1.06%
Italy	3.7	\$16.25	0.95%
Canada	2.8	\$12.29	1.11%
Spain	2.1	\$9.22	0.82%
Russia	2.1	\$9.22	1.19%
Brazil	1.8	\$7.90	1.00%
China	1.6	\$7.03	0.37%
Australia	1.5	\$6.59	0.96%
Mexico	1.5	\$6.59	0.87%
Korea S.	1.3	\$5.71	0.71%
India	0	\$0.00	0.00%

Source of data: International Monetary Fund, World Economic Outlook Database, September 2005.

In this framework, China should investment USD\$7 billion annually in emission reduction, as a financial contribution to meet the stabilization level of 2 degrees as the global target. In fact as described above, to meet its 11th 5-year plan targets, China has already spent much more than that allocated in M-GDR approach. Although in the long run, energy conservation and pollution reduction are in the country's long-term interests, requiring a developing country like China with limited capacity to take such a huge responsibility for the global common goods does not fit the UNFCCC principle of equity so that the reduction won't be effective or efficient. ICP allows China to use its national emission reduction plan exchanging for the international supports to fill the gaps of investment and technology for meeting the targets. This is the advantage of ICP, created in M-GDR approach.

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