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China's Dilemma in Climate Change Mitigation:
The Energy Problem

Bo Miao & Graeme Lang[1]

Abstract

The vulnerability of China to the adverse impacts of rising global warming is outlined, including projected impacts on coastlines, agriculture, water supply, land degradation, and public health, since these are important reasons why China, partly for reasons of national security, is increasingly addressing the climate change problem in national and international discussions. This paper then profiles China's greenhouse gas (GHG) emissions and illustrates how the pressure from the international community, especially that from the US, would impel China to make more substantial contribution to global climate effort. After examining China's coal-dominated energy mix, we review the current approaches undertaken by China to combat climate change. They are essentially programs that aim to increase energy efficiency and deploy alternative energies, thus reducing energy costs and bringing about ancillary climate benefits. China's active participation in the Clean Development Mechanism (CDM) is then discussed. We show that it appears to be impossible, with current or currently developing technologies such as Carbon Capture and Storage (CCS), to produce the 80% reductions in GHG emissions which scientists recommend over the next four decades. What other measures might be feasible for China to make more substantial contributions to global climate-change-mitigation efforts? China's dilemma is the need to sustain a developing economy which depends crucially on GHG-emitting processes. It appears to be impossible to do this without some radical restructuring of economic activity, since it seems that it cannot be done by some combination of greater energy-efficiency and substituting fossil fuels by renewables or nuclear power. An alternative over the longer term is to promote relocalization of production and exchange using local and regional renewable resources. There are many towns and cities in the world in which groups are planning and beginning to implement such changes. In fact, China is almost uniquely well-qualified to take this approach, and indeed, could become a leader in such innovations and such technologies. In the longer term, it is very much in China's national interest to follow this path.

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Introduction

China's importance in the international climate change regime cannot be underestimated. As one of the largest GHG emitters, and maybe the largest one though Chinese senior officials have repeatedly rejected such claims, it is a must for the international community to engage China effectively in any coordinated effort to combat global warming. Unlike any other conventional air pollution that is either local or regional, climate change is global and everyone has a stake. All nations will be affected to various degrees by the adverse impacts of the most far-reaching environmental problem that human society has faced since the end of the last ice age. China is not immune to such adverse impacts, though it may not be hit as heavily as some low-lying island countries. China's own research has pointed out that China is one of the most vulnerable nations to the potential risks in climate change (NDRC, 2007). It is therefore in China's own interest to work with other major emitters to moderate the rapid growth of GHG.

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However, it would be unrealistic to expect China to undertake the same emissions reduction commitments as other developed economies. China only accounts for a small portion of the GHG that have accumulated in the atmosphere in the past two hundred years. It has every reason to ask the developed nations who have historically emitted large volumes of GHG and currently have much higher per capita emissions to bear primary responsibility and take the lead in any mitigation action. The US, as the largest historical GHG emitter, has been refusing to undertake any mandatory responsibility to cut its emissions, and China has used US recalcitrance as an excuse to shun any binding duties. This scenario is very likely to change since the new US President Barrack Obama has explicitly expressed strong interests in making more substantial contribution to combat climate change, and the adoption of a mandatory cap-and-trade GHG emissions program is under heated discussion in the Congress. Once US is on board, China will be under greater pressure to make more constructive climate action. The latest visits by the Secretary of State Hilary Rodham Clinton and the House speaker Nancy Pelosi both highlight the importance of climate change collaboration between these two largest emitters. The latest news is that these two nations are negotiating a deal, a kind of joint agreement, in regard to a schedule for emissions reductions and overall climate policy, and this will be a big step as the world moves closer to the Copenhagen negotiations (Dyer, 2009).

The Chinese government is not blind to the potential costs that climate change could cause for its cities, its agriculture, and the sustainability of some regions of the country. It is promoting a series of energy-oriented policies and measures such as energy efficiency and renewables programs that would also generate ancillary climate benefits. The Central Government claims that it has effectively reduced 835 million tons of CO2 equivalent by energy conservation and promotion of alternative energies in 2006 and 2007 (State Council, 2008). But China’s aggregate GHG emission has continued to grow rapidly in the past few years, with no sign of slowing down. The dilemma is, with China’s heavy dependence on coal to fuel the burgeoning economy, can China effectively mitigate the GHG emissions while sustaining development and eradicating poverty?

In order to answer this question, this paper is divided into four sections. Section 1 will address the question of why China should care about climate change. The vulnerability of China to the adverse impacts of rising global warming is outlined, including projected impacts on coastlines, agriculture, water supply, land degradation, and public health. It is pointed out that it is in China’s own interest to work with other nations to prevent the catastrophic results of climate change from happening. Request from the international community, especially that from the US, would also play an important role in impelling China to make more substantial contribution to global climate efforts. China’s GHG emissions profile is also described in order to provide a better understanding of the nature of such international calls.

Section 2 reviews China’s action against climate change. It first examines China’s coal-dominated energy mix, showing that coal will continue to power China for a long period of time and the CCS technology would not be commercially viable within foreseeable future. It then discusses the energy efficiency and renewables programs that are promoted by the Central Government with the purpose of addressing issues like energy security but also produce remarkable climate benefits. As the largest host country for CDM, China’s active participation in this flexible mechanism offered by Kyoto Protocol is also reviewed.

After acknowledging that current climate-change-mitigation approaches are meaningful but far from adequate, section 3 explores what other measures might be feasible for China to significantly mitigate its GHG emissions. It is suggested that an alternative over the longer term is to promote relocalization of production and exchange using local and regional renewable resources. The essence of relocalization and initiatives taken by many towns and cities overseas were briefly examined. The section also discusses China's advantages in marching on this path, especially those in the agriculture. The last section provides some concluding remarks.

Section 1: Climate Change: Why Should China Care About It?

1.1. Reason I: Vulnerability of China

Experience tells that one will not act unless it is in its own interest to do so. The grave long-term challenges that are posed by climate change have drawn increasing attention from all nations, including China. As one of the major greenhouse gas emitters, Chinese policymakers are not blind to the adverse effects that could be caused by the continuing concentration of greenhouse gas in the atmosphere. In 2007, the National Development and Reform Commission (NDRC) published *China's National Climate Change Programme*, acknowledging that China is one of the most *vulnerable* countries to climate change, which has already had certain impacts on it in various ways. "Vulnerability" could be understood as the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change (IPCC, 2001). Indeed, China is climatically vulnerable in two senses:

On the one hand, the current and likely adverse impacts of climate change on China are huge and could be even worse than many expect should the development pattern fail to be significantly changed. The following description of those adverse impacts is primarily drawn from *China's National Climate Change Programme* (NDRC, 2007, pp.16-19) and *China's Policies and Actions for Addressing Climate Change* (State Council, 2008).

First, China's agriculture and livestock industries have experienced certain changes with regard to the rising temperature, mainly shown by the 2-to-4-day advancement of spring phenophase since the 1980's. Declining crop yields are a risk. Rice production is sensitive to increased temperatures, and thus can be affected by climate change. Forests and other natural ecosystems in areas where average temperatures are increasing would also be affected. The frequency and intensity of forest fires and of insect and disease outbreaks in forests are likely to increase as a result of climate change.

It is expected that future climate change would also lead to expanding deserts and shrinking grassland in some arid regions in western parts of China. Desertification is already a serious problem for the country, and the resulting loss of grazing land and farmland, 1along with the inevitable dust storms, all of which bring huge costs for the country, could be worsened by global warming.

Second, global warming would challenge China's water resources and distribution. One of the biggest longer-term impacts would be the melting of glaciers on the Tibetan plateau, because runoff from these glaciers provides the water for some of the greatest rivers in East and Southeast Asia, including the Yangtze and Yellow Rivers in China. Vast areas of agricultural production depend on the flow of water from these glaciers, that is, from winter snow-pack which melts through the spring and summer of each year. If global warming leads to earlier runoff from snow-pack, the summer flow from glaciers can be greatly reduced, as is apparently already occurring in the western U.S. Water supply for agriculture, industry, and domestic uses in northern and central China would be threatened, even if precipitation increases in parts of southern China. This is of course a long-term projection. But the glacier area in north-western China has apparently already shrunk by 21% according to some accounts, and the thickness of frozen earth in Qinghai-Tibet Plateau has declined in recent years. A decreasing trend in runoff has been observed during the past 40 years in China's six main rivers.

In early 2009, China experienced the most severe drought in some northern regions in the past fifty years and significant losses were reported. Some northern river basins, particularly the Haihe-Luanhe River basin, are clearly very vulnerable to climate change.

Third, the accelerating trend of sea level rise along the Chinese coast in the past 50 years is clear evidence of the impacts of climate change upon coastal environment. China is not as exposed to rising sea levels as some other countries such as Bangladesh, but some of China's richest agricultural regions, such as the Pearl River Delta, are close to sea level and could experience decreased production as saltwater intrusions onto land and into river deltas increases. Coastal erosion, seawater intrusion, mangrove and coral reef degradation are observable and expected to further deteriorate. Some major cities such as Hong Kong, Guangzhou, Xiamen, and Shanghai would also be affected by sea-level rises. The worst-case scenarios for sea-level rise (e.g. from melting of the Greenland Icecap) would force the abandonment of some of these cities. But less extreme and currently more probable scenarios of sea-level rise would also produce heavy costs for cities and for coastal agriculture. Global warming will also evidently increase the severity of extreme and costly weather events such as typhoons and storm surges, to which China is especially vulnerable because of its long coastline and exposure to storms moving toward the coast from the south-western Pacific oceans.

Fourth, climate change would also increase the intensity and frequency of heat waves, which have been devastating already to populations in Europe and Australia, and would also facilitate the northward spread of diseases such as malaria and dengue fever from Southeast Asia into southern and central China.

On the other hand, China currently lacks the personnel, technical and financial resources to deal with these kinds of impacts caused by climate change and therefore might suffer great losses in the future, both in urban and rural areas.

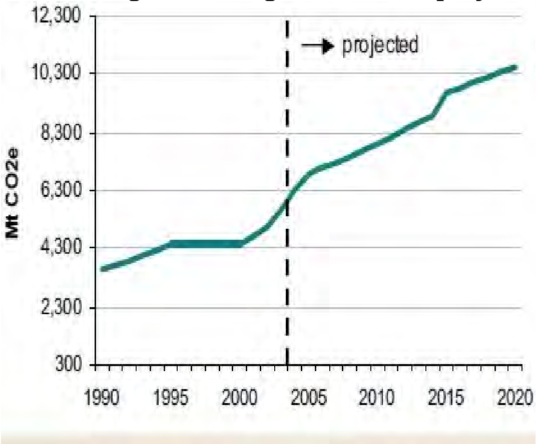
These climate change-related impacts could be even worse should China, along with other major economies, fail to change significantly their development pattern and effectively control their greenhouse gas emissions.

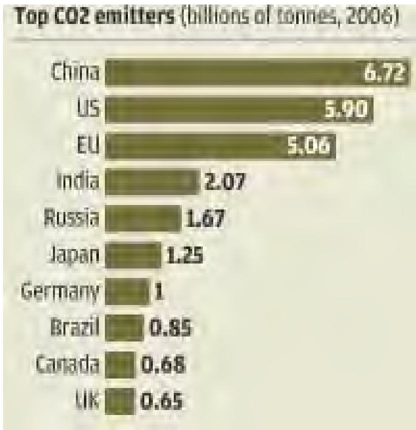
1.2. Reason II: Pressure From The International Community

Meanwhile, the international community's calls for China to undertake meaningful action to control its greenhouse gas emissions have never ceased since the day climate change became an issue. In order to understand the nature of such calls, it is necessary to first take a look at China's GHG emissions scenario.

The emission of China's greenhouse gas has certain interesting features. Although China historically only accounted for a relatively lower percentage (7.3% from 1850−2000) in globally cumulative greenhouse gas emissions, it has kept increasing its share in the last decade up to 14.8% in 2003 and became the second largest annual emitter in absolute terms in that year, where GDP and total population are the decisive determinants. The rising trend has continued and it is claimed by many researchers that the annual greenhouse gas emissions in China have already surpassed those of the US and that China has already became the world's largest emitter (IEA, 2007; see Figure 2). Furthermore, given China's continuously soaring energy-related CO2 emissions, what could be expected in the coming decades is continuing increases in greenhouse gas (Figure 1).

Figure 1: China's greenhouse gas trends and projections; Figure 2: Top carbon dioxide emitters

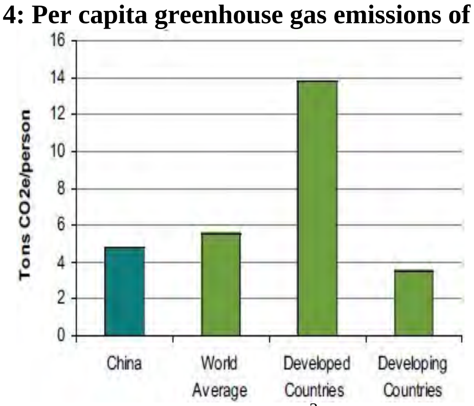


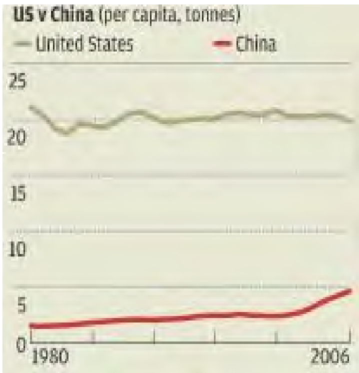


Source: Pew Centre, 2007[2]   Source: Shi, 2009

However, in sharp contrast to the enormous overall amounts, China's greenhouse gas emissions, in per capita terms, depict a strikingly different picture, in which China only ranks 97th globally in 2004, just slightly higher than the average for developing countries but below the world average (NDRC, 2007, p.6). A recent report states that China's per capita emissions are 78 percent lower than that of the US, although China's per capita emissions are growing at a rate four to six times as fast as those of the US (Asia Society & Pew Centre, 2009, p.19). Along with the sharp increase in overall greenhouse gas emissions in the past a few years, it is reported that China's per capita emissions are approaching the world average (Figure 3; see also Tu, 2009, p.12).

Figure 3: Per capita greenhouse gas emissions in 2004
Figure 4: Per capita greenhouse gas emissions of US and China





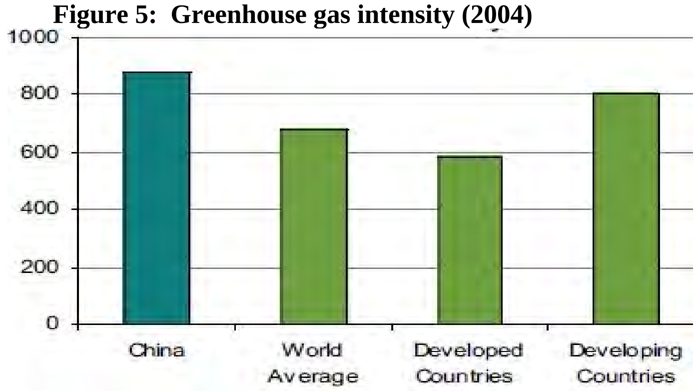
Source: Pew Centre, 2007[3]   **Source: Shi, 2009.**

It is also interesting to observe the decrease of China's carbon intensity − the level of CO_2 emissions per unit of economic output. Carbon intensity not only serves as a strong determinant of a country's overall emissions, but also reflects the energy intensity and fuel mix within carbon-related industries (Baumert et al., 2004, p.4). China has offered a striking case in this regard. As of 2004, China's carbon intensity was above the world average, and above the average for developing countries (Figure 5). But China's carbon intensity evidently fell 47%, while GDP grew 162% from 1990 to 2000 (both much as a result of privatisation and introduction of market reform). In comparison, between 1990 and 2000, the

[2] 'Climate Change Mitigation Measures in the People's Republic of China', Pew Centre on Global Climate Change, 9 April 2007. Available HTTP: <http://www.pewclimate.org/docUploads/International%20Brief%20-%20China.pdf> (accessed 18 January 2009).
[3] Ibid.

greenhouse gas intensity of the US economy declined by 17.5% (Robert & Kyle, 2003). International Energy Agency (IEA) also confirms that China's emission intensity in 2004 continued to decline.

Figure 5: Greenhouse gas intensity (2004)



Source: Pew Centre, 2007[4]

However, some less optimistic predictions with regard to China's decreasing trend of carbon intensity exist, such as "*It remains to be seen whether these trends are anomalous one-time shifts reflecting particular circumstance … the opening of China's economy to market forces … or whether they suggest the potential for a longer-term decoupling of economic and emissions growth*" (Baumert et al., 2004, p.6). It is argued by some observers that carbon intensity of China may not be able to continue to decline due to the rapid growth in industrial demand, its heavy dependence on coal and the increasing constraint on securing oil from overseas (Garnaut et al., 2008, p.3). Some even claimed that '*China's trend of decreasing energy intensity reversed between 2002 and 2005 with energy growth surpassing economic growth…China is now four times as energy intensive as the US and nine times less efficient than Japan*' (Asia Society & Pew Centre, 2009, p.19). This claim is not invalid given that China indeed invested more on heavy industry since 2001 in order to maintain the two-digit growth rate. There also exist arguments that Beijing's impressive greenhouse gas reduction achievements in late 1990s is largely due to an embarrassing underreporting of coal statistics (Tu, 2009, p.13). However, despite all these arguments, it is safe to say that the Beijing government has remarkably reduced its energy intensity and has thereby produced climate benefits.

Indeed, although China's low per capita GHG emissions can still provide some support in international climate negotiations, the soaring growth rate in its absolute emissions has made it spotlight in any climate talks. The debate with regard to China's climate responsibility has become even more heated since China recently replaced the US as the largest greenhouse gas emitter.

While developed economies such as European Union have been trying to introduce various incentive programs to get China more actively involved in climate-change-mitigation action, the play between China and the US over the international climate change regime deserves special attention.

During the eight years of the Bush regime, China used US inaction as an excuse to shun constructive greenhouse gas mitigation efforts, and the U.S. used Chinese inaction for the same purpose. Neither of these two largest greenhouse gas emitters undertook any mandatory obligations to set a limit on or reduce its emissions under the Kyoto Protocol. Nevertheless, there are new trends in the climate strategy of the US. In 2009, a number of senate bills were under active discussion in the Congress, and it is likely that a mandatory emissions control scheme will be put in place in the US no later than 2010, under which the

[4] Ibid.

global politics of climate change will be thoroughly transformed (Clauseen, 2007). Driven by concerns about the negative economic effects such as losing competitive advantage to those without the same emissions controls as the early-movers, in particular China, the US will have strong incentives to drag China into the global climate effort and insist that China fulfil its share of responsibility as well.

The cover that China has been hiding behind will be eliminated once the US takes the lead and commits itself to mandatory emission reductions, which would probably come true since the new president, Barrack Obama, has expressed strong interests in combating climate change. It is reported that the President '…has pledged to bring emissions down to 1990 levels by 2020 and endorsed a bill that would cut emissions by 17 per cent from 2005 levels in 2020 - a reduction of 5 per cent from 1990 levels, according to EU calculations' (Bloomberg, 2009). The Energy and Commerce Committee in the House just passed the Waxman- Markey bill, a climate and energy bill that incorporates the establishment of a nation-wide emissions trading scheme, the use of renewable energy and the long-term target of reducing GHG emissions. While it is a long process before such bill can turn into law, the passage has illustrated to some extent the legislature's determination to set mandatory limits on US's GHG emissions. In addition, a number of states have participated in regional initiatives such as Regional Greenhouse Gas Initiative and Western Climate Initiative that set up cap-and-trade systems to control their GHG emissions.

Experience has proved that when the US is prepared to lead, others, too, will often be far better able to muster the necessary political will (Clauseen, 2007). The recent call for joint efforts to curb greenhouse gas between the US and China by Secretary of the State Hilary Rodham Clinton when she visited China in February 2009 may indicate the Obama administration's hope to make climate change the centerpiece of a broader, more vigorous engagement with China.[5] Even the outspoken China critic and US House Speaker Nancy Pelosi puts climate change on top of agenda and steers away from human rights in her latest visit to China (SCMP, 2009). All of the five members of the delegation led by her are members of the House Select Committee on Energy Independence and Global Warming. In fact, there are news claiming that China and the U.S. are apparently negotiating 'deal', a kind of joint agreement, in regard to a schedule for emissions reductions and overall climate policy (Dyer, 2009). US Energy Secretary Steven Chu recently said that the US may accept targets for cutting its greenhouse gases in an international treaty, even if China does not (Bloomberg, 2009). Observers also state that the cooperation between China and US on energy and climate change would produce mutual benefits for both parties (Asia Society & Pew Centre, 2009).

In the future climate framework, whether multilateral or otherwise, while China may not be required to take on quantified greenhouse gas emissions limits as the developed countries do, it might have to demonstrate its sincerity in contributing its fair share to the international climate efforts by making some forms of binding commitments. In fact, the Bali Roadmap which was passed in 2008 by the United Nations Framework Convention on Climate Change conference has already called for 'measurable, reportable and ***verifiable*** nationally appropriate mitigation commitments or actions' from developing countries including China. It is expected that the 2009 Copenhagen conference will witness more climate progress from both US and China.

Indeed, it is a fact that China's greenhouse gas emissions, even with tremendous uncertainties in national-level projections, will continue to rise sharply due to the growth of its economy, population and energy consumption and heavy reliance on coal. Under these circumstances, it will eventually become a must for China to put in place concrete action in

[5] 'Clinton paints China policy with a green hue' authored by Mark Lander, *New York Times*, 22 February 2009. Available HTTP: <http://www.nytimes.com/2009/02/22/world/asia/22diplo.html?_r=1> (accessed 23 February 2009).

response to the international community's request, particularly that from the US, for its more meaningful participation in climate-change-mitigation efforts (Cao, 2008).

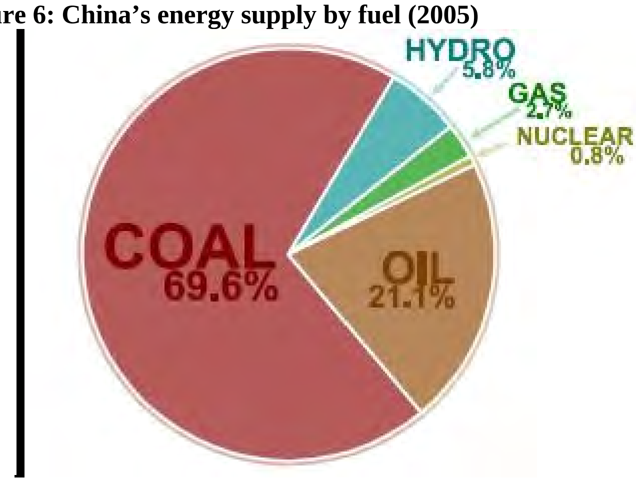
Section 2: China's Action Against Climate Change

Climate change is not a new concept for the Beijing government but it has developed slowly. China has not yet established an orchestrated national climate regime that provides effective regulatory mechanism, though it did set up some climate committees and published a series of white papers about climate (State Council, 2008). As will be discussed later, apart from the Clean Development Mechanism (CDM), the current climate change-mitigation policies in China are energy efficiency and renewable programs, which are essentially energy-oriented-and-targeted but produce ancillary climate benefits. Most of the GHG emissions in China take the form of CO_2. It is reported that the share of CO_2 in China's total greenhouse gas emissions is 83% in 2004 (NDRC, 2007, p.6). As emitting CO_2 in China is primarily a byproduct of energy production and China's emissions are dominated by heavy industry, it would be useful to first outline China's energy profile in order to obtain a better understanding of China's action against climate change.

2.1. Energy Profile: Coal-Dominant Energy Mix

As a country rich in coal—nearly 13 percent of all the known mineable coal still in the ground is in this country—it is natural to find that China's primary energy mix is dominated by this carbon-intensive fossil fuel (British Petroleum, 2006). In 2005, coal contributed more than 69% of China's energy use (Figure 6) including approximately 80 percent of its electricity generation, while oil accounted for around 20%, natural gas less than 3%, hydro, nuclear and others together approximately 7%.(China's Statistical Yearbook, 2006).

Figure 6: China's energy supply by fuel (2005)



Source: China Statistical Yearbook

In addition, China has recently witnessed a fast growth of coal power plants. In 2006 and 2007 alone, approximately 170 gigawatts (GW) of new coal power capacity were installed in China, equivalent of about two large coal power plants per week. There are currently more coal-fired power plants in China than in the US, the UK, and India combined (Asia Society & Pew Centre, 2009, p.20). In fact, burning coal is the largest contributor to $CO_{2,}$ not only because it dwarfs the consumption of natural gas and oil in absolute terms, but because coal combustion emits almost twice as much CO2 per unit of energy as does the combustion of natural gas, whereas the amount from crude oil combustion falls between coal and natural gas.

The implication of China's heavy reliance on coal for its energy supply is two-fold: first, the operations of desulphurisation equipment or other in-use coal cleaning technologies that reduce traditional air pollutants such as SO_2 did little to mitigate the emission of CO_2. It indicates that when coal consumption expands, which is inevitable under its current policy scenario, it will be equally inevitable for China to emit more greenhouse gas. Second, as coal is more carbon-intensive than other fossil fuels, China's CO_2 emission intensity of energy consumption is and will continue to be relatively high. As a result, China's per capita CO_2 emissions will approach the world average at a fast pace while other major emitters, such as OECD countries, are more diversified in energy supply and rely less on coal.

The coal-dominant energy mix is unlikely to be significantly changed in the near term, which is absolutely unavoidable in a country that is developing rapidly and is so heavily dependent on coal as the fuel to light up the cities, run the trains, and so on. For alternatives to coal, China is having a difficult time in increasing domestic oil production, and securing oil supply from overseas is not always easy (Lang and Miao, 2008). The current global economic turndown may offer China some opportunities in pursuing more overseas oil reserves. It is reported that '…China has committed more than US$50 billion to loans-for-oil agreements with Russia, Kazakhstan, Venezuela and Brazil since February' (Richardson, 2009). Should these deals be finalized, China would be able to obtain more than one third of 4.1 million barrels it currently imports a day.

Studies also show that China's gas production is increasing but not fast enough to satisfy demand growth (Rosen & House, 2007). In effect, although China has discovered new gas fields in Sichuan and Erdos Basin and made enormous efforts to obtain gas from countries such as Australia, Indonesia, Malaysia, Russia and central Asia, it is believed that it would be a daunting task to meet the forecast four-fold increase in demand which is largely driven by the fast-growing chemicals industry and an urbanization-led need for clean household heating and cooking fuel (Downs, 2006).

It is a fact that this most carbon-intensive fossil fuel will continue to engine China's burgeoning economy at least in the short to medium term. The Chinese government is not blind to the air pollution caused by burning coal. It formulates a series of polices to retire old, outdated coal power plants and replace them with new, more efficient ones. It is reported that '…China has since become the major world market for advanced coal-fired power plants with high-specification emission control systems' (IEA, 2009). With the installation of more efficient coal power plants such as the one recently build in Tianjin that uses extremely hot steam, it is likely for China to greatly increase the average efficiency of its coal-fired fleet and accordingly reduce the emission of CO2 per unit of electricity it generates. Experts expect that the application of newest technology would produce a cut of more than one third of the CO2 emissions compared to the weakest one (Bradsher, 2009a). It is also predicted that China may increase the average efficiency from 32 percent in 2005 to around 40 percent by 2030 by installing more supercritical units (Asia Society & Pew Centre, 2009, p.28).

However, it should be noted that only 60% of the newly built coal-fired power plants use advance technologies that improve their efficiency, and the numerous inefficient power plants that China built in the past decade will remain in operation for a long period of time. The overall amount of CO2 emissions from China's heavy reliance on coal is bound to increase rapidly. The question is, can China continue its reliance on coal in a carbon-constrained world? Or put another way, can China successfully deploy low-emissions or zero-emissions coal technology, such as Carbon Capture and Storage (CCS) to help abate the GHG emissions from coal-fired power plants?

CCS is a technology that captures CO2 either before combustion or after combustion, compresses the captured CO2 and transports it through pipelines for storage in deep, underground geological formations such as depleted oil fields (Asia Society & Pew Centre, 2009, p.29). The CCS is promising in controlling CO_2 emissions because should it be adopted, a coal-fired power plant will virtually emit zero greenhouse gases. The CCS technologies have been widely researched by many nations, but many of them are still at very early stage and there are only a few small-scale demonstration projects. China is also devoting resources to the CCS research with other international partners. In collaboration with the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO), Huaneng Power Group (China's largest electricity generator) started running a 3,000-ton post-combustion carbon capture pilot project near Beijing in 2008 (IEA, 2009, p.106). The CO_2 captured is not stored but used for beverage production. Other proposed demonstration projects including GreenGen (a 400-megawatt IGCC plant with CCS to be added by 2020) and Near Zero Emission Coal are also under planning (Asia Society & Pew Centre, 2009, p.29).

The major hurdle for wide application of CCS is cost. It is estimated that the electricity produced by a coal power plants that uses CCS would be 75% to 100% more expensive than the electricity produced by conventional coal power plant (IEA, 2009, p.106). The concern of 'energy penalty' of running the capture equipment should not be ignored, either (Asia Society & Pew Centre, 2009, p.30). With current CCS technology, the energy that is required for capture is significant and may reduce a plant's combustion efficiency by roughly one third. While transportation from power plant to storage site is a further costly complication for carbon sequestration, the storage of the captured CO_2 is another problem. While some initial assessment of China's storage capacity has been conducted, it is too early to conclude that China would be able to store the CO_2 generated by its enormous amount of coal-fired power plants. Indeed, the volume of CO_2 currently generated by combustion of coal, when compressed for storage, would be much larger than any current storage sites, which in any case are usually very far from existing or planned power plants. The magnitude of the CO_2 emitted by all China's coal power plants would undoubtedly make the transportation and storage a daunting task.

Neither can the risk involved in the potential leakage of stored CO_2 be underestimated—the leaked CO_2 could be lethal. Insurance companies would not act unless scientific research can convincingly ensure that leakage would not be a problem; and without the financial assurance from the insurance companies, it is hardly possible to expect any large-scale CCS project which normally demands huge amounts of investment to kick off. In addition, some researchers have argued that burying carbon dioxide from coal-power plants could increase the emissions of other pollutants such as NO_x and SO_2, casting some shadow on this highly-acclaimed technology (Barry, 2008).

Indeed, whereas the international community has admitted that technologies such as CCS are key to the continual use of coal, it is widely agreed that large-scale promotion of CCS would not be commercially viable until 2030. It is a fact that China is actively participating in the research and development of this clean coal technology, but it is unrealistic to expect that China would adopt a technology which is not yet in commercial use in the developed economies.

2.2. Promoting Renewable Energy

No matter how efficient it is, burning fossil fuels still emits GHG. It is suggested by many that the real solution for combating climate change would be a complete shift to renewable energy such as hydro, wind, solar, biomass, tidal, etc. As the renewables are virtually zero-carbon emitting, powering the world by them would absolutely alleviate the concern about the continuing concentration of GHG in the atmosphere, though other concerns may arise along with their wide use.

While obtaining 17 percent of its electricity and 7 percent of the primary energy from renewable sources in 2008, the central government in Beijing is making efforts to further diversify the supply with hydro, nuclear and other renewable power. It announces a target of 16% of primary energy from renewable energies and 20% of electricity capacity by 2020. In order to achieve the target, the Beijing government has put in place a series of policies and measures that provide various forms of incentives to enterprises (Asia Society & Pew Centre, 2009, p.37). However, the development of non-carbon emitting energies in China is complicated.

Hydropower is currently the primary source of China's renewable electricity. The production of hydropower increased by 10.8% in 2007 and provided for more than 6% of China's overall energy need in that year. Much of the increase was contributed by the Three Gorges Dam that was newly put to use and expected to provide China with 18,000 megawatts of energy, more than ten percent of China's total electricity needs. The benefits and damages that would come along with this large-scale campaign have been well documented. Whether this project would be an economic success or an ecological disaster remains an open question, but the fact that it has received considerable domestic as well as international criticism has cast some shadow on its future (Boland, 1998 and Heggelund, 2004). Meanwhile, it is not rare to see strong political resistance, mainly from the displaced people and environmental groups, to new major hydropower projects such as those planned to be build on Nu River and Mekong River. The Central Government's decision to postpone those constructions until the controversy was settled and the environmental concern properly addressed has indicated the government's cautious attitude toward massive hydropower programs.

The latest news is that MEP has suspended two new large dam constructions on upper Yangtze River as the companies started construction without passing environmental impact assessment.[6] These two dams are part of the ambitious program of building 12 hydropower projects along the Jinsha River that flows from Qinghai province to Yunnan and Sichuan provinces, which would altogether produce an equivalent amount of electricity to the Three Gorges Dam when completed. However, voices like such construction would severely damage the local biodiversity have never ceased since the construction plan was proposed. In addition, the declining water resources would also take a toll on the development of hydroelectric facilities.

In regard to nuclear power, China has recently expressed strong interests in accelerating the build-up of nuclear plants.[7] It is reported that China plans to build eight nuclear plants from 2009 to 2011 with a total capacity of more than 10 GW, exceeding the overall capacity in all the past years.[8] The first inland nuclear plant is to be located in Hebei province and expects to commence construction in early 2009.[9] Despite the continuing opposition to building nuclear plants by many environmentalist groups (e.g. Greenpeace), some analysts in China and overseas argue that China can and should try to reduce coal consumption through replacing some electricity production from coal with electricity

[6] 'MEP suspended the application from Huadian and Huaneng electricity group', New Beijing Report, 12 June 2009, Available HTTP: <http://news.163.com/09/0612/02/5BIV63C2000120GR.html >(assessed 15 June 2009).

[7] 'The Third-generation Nuclear Power Plants is to be laid out in China', *Phoenix Finance*, 2 September 2008. Available HTTP: <http://finance.ifeng.com/zq/hybg/200809/0902_932_757826.shtml> (accessed 23 February 2009)

[8] 'China will promote the self-development of nuclear power plant', *Caijing*, 19 February 2009. Available HTTP: < http://www.caijing.com.cn/2009-02-19/110071355.html> (accessed 24 February 2009).

[9] 'China expects to build the first inland nuclear plant in 2009', *Xinhua Net*, 7 December 2007, Available HTTP: <http://news.xinhuanet.com/newscenter/2008-12/07/content_10469198.htm> (accessed 23 February 2009).

production by nuclear power in the medium term.[10] The Daya Bay nuclear power plant has been supplying about 30% of the power to one of Hong Kong's two major electrical utilities without problems for more than a decade. The argument of these analysts is that the risks and likely damage from substantial global warming are orders of magnitude greater than the risks of accidents and the problems of storage of waste associated with nuclear power plants such as the one at Daya Bay. Concerns such as China's coal reserve is finite and might not be able to eternally sustain the booming economy also partly encourage China to pursue further the development of nuclear power.

It is also possible that with new technology such as the 'pebble bed' reactor, which is currently being tested in China, the country may be able to reduce risks and costs involved in building and operating nuclear power plants.[11] It is therefore more likely for China to promote the use of this "clean" power on a larger scale and help reduce greenhouse gas emissions.

On the other hand, we cannot be blind to the potential risks in nuclear power. It may be too early to conclude that China has obtained nuclear technologies that are mature enough in all aspects to support extensive construction of nuclear power plants and that a boom in construction of nuclear power plants will occur. It is fair to say that although the central government has indicated its support for China's nuclear power development and some technological progress has been achieved, it still remains to be seen how those policies and measures will actually play out.

The development of other renewable energy is also encouraging. Wind power is becoming cost-competitive in certain areas and China has become one of the world's largest markets for wind turbines along with US and Spain. At the end of 2007, China's installed base of wind power totaled just over 6 gigawatts (GW), making China the fifth largest producer of wind power, after Germany, the U.S., Spain and India. As a consequence of the rapid build-out of wind power projects in China, in April 2008 the National Development and Reform Commission revised its 11th Five Year Plan Period plan for wind power development from 5 GW to 10 GW by 2010. Wind power industry statistics show that by the end of 2008 China's total installed base of wind power production will have already reached 13 GW, two years ahead of the revised plan. Some experts are estimating that by 2010, the total installed capacity for wind power generation in China will reach 20 GW and that by 2020 China's installed base of wind power will total 100 GW.[12]

Meanwhile, solar-water-heating is widely used by Chinese families due to the relatively low costs. China is also the world's largest producer of photovoltaic (PV) cells. As solar-generating electricity is generally ten times more expensive than that from traditional coal-fired power plants, 98% of China's photovoltaic cells are exported overseas (Xin, 2009). The current economic turndown is giving most of China's PV a hard time as the demand from overseas market is shrinking dramatically. The Ministry of Finance issued *Application Guidelines for Demonstration Projects of Solar Photovoltaic Building* on 20 April, 2009 and provides a maximum subsidy of 20 RMB per installed watt for eligible applicants (Ministry of Finance, 2009). Since the current installation cost for PV cells in China is roughly 24 RMB/watt, the demonstration projects can significantly reduce the installation cost to as low as 4 RMB/watt with the maximum subsidy. It is estimated that the electricity price from these

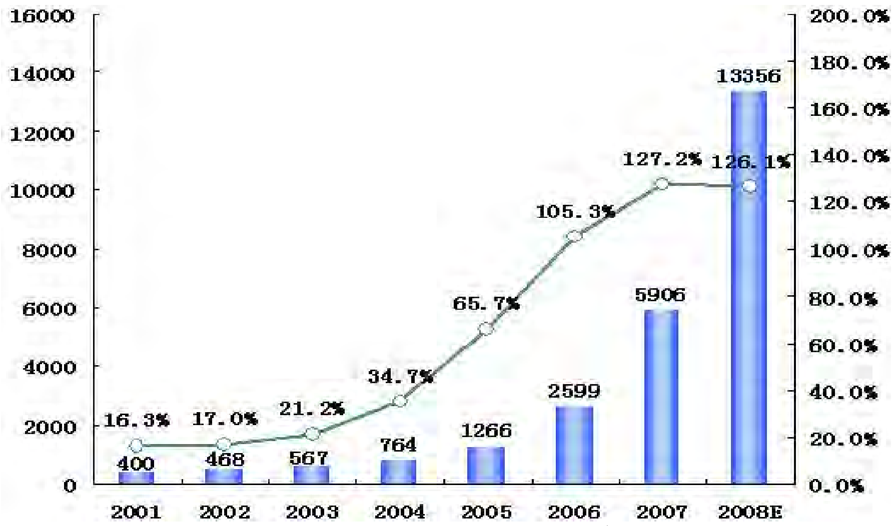
[10] 'China should promote significant the construction of nuclear power plant in inland area', *China News, 19 June 2008.* Available HTTP: <http://www.chinanews.com.cn/cj/cyzh/news/2008/06-19/1286065.shtml> (accessed 23 February 2009).

[11] 'Let a thousand reactors bloom' authored by Spencer Reiss, *Wired. Issue 12.09,* September, 2004. Available HTTP: http://www.wired.com/wired/archive/12.09/china.html?tw=wn_tophead_7 (accessed 23 February 2009).

[12] 'China's Wind Power Industry: Blowing Past Expectations' authored by Lou Schwartz & Ryan Hodum, 16 June 2008. Available HTTP: http://www.renewableenergyworld.com/rea/news/story?id=52764 (accessed 23 February 2009).

projects would therefore even have a slight competitive advantage over electricity from other sources (Xin, 2009).

Figure 7: China's wind power capacity and increasing trend from 2001-2008



Source: Huajing Shidian Research Centre, 2008（Column: installed capacity in MW; Curve: growth rate)[13]

Indeed, the rapid development of renewable energy, including building more nuclear plants and wind farms, would provide more electricity from non-coal sources and help abate China's greenhouse gas emissions in absolute terms. Nevertheless, there is bound to be a long way to go before renewable energy can make a significant dent in China's rising overall power demand given the aggregate amount of energy that are needed to fuel China's booming economy (Lang and Miao, 2008). For now, it is implausible to expect that they would reduce substantially the consumption of coal and other fossil fuels, and lead us into a carbon-free world at anywhere near current rates of energy consumption. But in the medium to long term, renewable energy could help China address the great dilemma caused by the heavy dependence on coal and the urgent need to mitigate greenhouse gas emissions.

2.3. Improving Energy Efficiency and Conservation

Another important energy policy that would produce significant climate benefits is the government's attempt to reduce energy consumption through greater efficiency and conservation. China sets an ambitious goal of cutting energy intensity (energy consumption per unit of GDP) by 20% below 2005 levels by 2010. It is estimated that a 20 percent energy intensity improvement can translate into an annual reduction of over 1.5 billion tons of CO_2 by 2010, making this largely local-pollution and energy-security-oriented effort one of the most significant carbon mitigation initiatives in the world (Lin, 2008).

The pillar project of achieving the 20 percent reduction target is the Top 1000 Enterprises Program (including 1008 enterprises actually), which was launched by the National Development and Reform Commission (NDRC) in 2006 and aims to improve the energy efficiency in China's 1000 largest enterprises that devour one third of the country's primary energy. It is expected that these 1,008 energy-consuming enterprises will achieve an overall reduction of 450 million tons of CO2 by 2010. Even for a large emitter such as China, this amount of reduction is not small, if we take into account the reduction target of 300

[13] 'China's wind power development in 2008', *Huajing Shidian Research Centre*. Available HTTP: <http://www.chinahyyj.com/news/r_20081218143332925628.html> (accessed 23 February 2009).

million tons of CO2e put forward by EU in their Kyoto commitment. It should be noted that local governments are also required to develop similar programs with an additional 100,000 smaller firms in order to achieve the 20% reduction national goal by 2010.

Meanwhile, in an announcement made in early 2007, NDRC was making efforts to retire a wide range of inefficient industrial plants. China is also improving the fuel economy standards for passenger vehicles fleets. The current standards are more stringent than those in Australia, the US and Canada (although less stringent than those in Japan and the EU). What is more important is that China revised the Energy Conservation Law in 2008, putting forward new and more stringent efficiency standards for buildings, industries and appliances.

However, these energy-oriented policies do not always perform as planned. It is reported by NDRC that 7.8 percent of the 1008 enterprises failed to meet their energy saving targets in 2007 (Xinhua Net, 2008). If we take into account local officials' conventional practice of massaging the data, chances are good to have a less aspiring percentage of compliance. China also failed to meet the energy intensity reduction target both in 2006 and 2007, though 2008 stands a relatively good chance to meet the target. Reasons for that are complicated: first, the target set by the central government is deemed as, though laudable, too ambitious; second, it takes considerable time for industry to invest in energy-saving facilities and change their business-as-usual behavior. It also takes time for the investment to produce actual energy-saving results; third, it is not easy for China to shift away from a heavy-industry-led consumption which is relatively energy intensive, as capital has been locked in on the basis of expected returns; fourth, the order to shut down small energy inefficient firms was not fully obeyed by local officials; and fifth, the financial costs of improving energy efficiency are rarely small in amount for selected firms, who cannot always obtain adequate financial assistance from the government. The prospect for China achieving the 20% reduction goal appears dim.

Aside from targeting large stationary enterprises, transportation is another sector that China can make great improvement in both ensuring energy security and combating climate change. The most significant case is the development of electric vehicles.

Unlike the hybrid car that still consumes oil and emits GHG, electric car produces no emission at the tailpipe, and in most models, it does not even has a tailpipe, making it virtually zero-carbon emitting. Many have expressed interest in developing electric vehicles including China. The Central Government recently put forward the goal of becoming a world leader in electric car by 2012 with the purpose of creating jobs, reducing urban pollution and decreasing oil dependence (Bradsher, 2009b). In order to achieve the goal, the government has allocated large amount of funds to the electric car research. It also runs a pilot program in 13 cities which offers a subsidy of up to $ 8,800 to each electric car that joins the taxi fleet or is purchased by the local government agencies (Bradsher, 2009b). Complimentary infrastructure such as charging station for electric cars is also under construction in Beijing, Tianjin and Shanghai. It is reported that China aims to boost its production of hybrid or electric vehicles from 2,100 in 2008 to 500,000 by 2011 (Bradsher, 2009b).

In fact, some companies in China, like Shenzhen-based BYD Auto, China's Tianjin Qingyuan Electric Vehicle Company and Hafei Auto Group, have successfully developed several electric car models and passed strict safety test. But how to commercialize them in the market remains an open question in China as it does in other countries—even with the government's subsidy, the retail price of these electric cars are still much more expensive than the gasoline-engine counterparts. Other concerns about its development in China also exist. For instance, the demand for electricity in China is so huge that it may leave little room to provide sufficient amount of electricity to recharge the battery for the large scale promotion of electric cars.

Electric vehicles also have an eco-label—the Well-to-Wheel CO2 emissions of electric vehicles is always lower than those of conventional cars. The question is, as electric cars replace the burning of gasoline and diesel fuel by the burning of coal to produce electricity, will there be great ‘emission saving’ for China?

The answer is closely related to the emission intensity of China’s existing electricity infrastructure. As previously discussed, 80 percent of China’s electricity is produced by coal, and it could be expected that most of the electricity that will be used to recharge the battery for electric cars would be provided by coal-fired power plants. Bearing in mind the fact that many of China’s coal power plants are still inefficient, using electricity coming from carbon-intensive fossil fuels would negate to a great extent the climatic benefits brought by the efficiency advantages of electric vehicles. A McKinsey & Company report states that ‘…given China’s reliance on coal-fired plants for electricity, electric vehicles today only have a 19 percent carbon abatement potential over current internal combustion engine technologies.’ (Gao, et al. 2008).

However, electric cars could produce better environmental benefits if more renewable energy is introduced to the grid. By diversifying the energy source to fuel cars, China would be able to achieve as much as 49 percent carbon abatement potential (Gao, et al. 2008). However, it is a long way for China to realize the high carbon abatement potential since its coal-dominant energy mix would not be significantly changed in the foreseeable future.

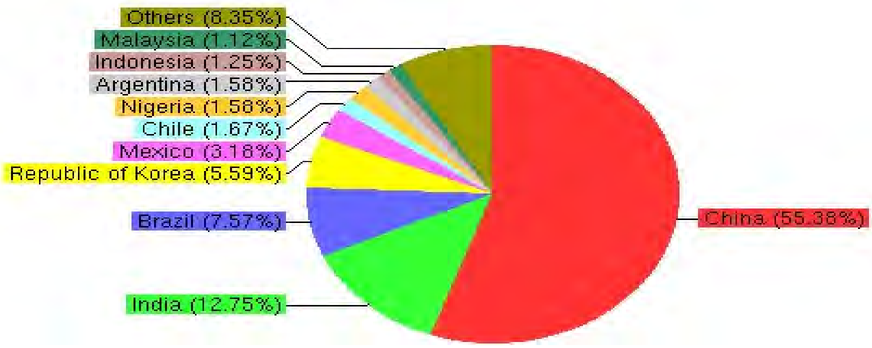
Indeed, these energy-oriented polices do not aim directly to reduce China’s GHG emissions, but they have produced remarkable climate benefits in the absence of a concerted national climate policy providing effective regulatory mechanism. The Chinese government claims that by energy conserving and using renewable energy, China reduced 835 million tons of carbon dioxide equivalent in 2006 and 2007 (State Council, 2008). These climate change mitigation-related policies and measures are important in China’s efforts to cut GHG emissions. It should be noted that China has also launched a campaign of nation-wide tree-planting and reforestation and enhanced ecology restoration and protection, which also cut the emission of CO2. And we should bear in mind that the effective control on the growth rate of population through family planning has contributed greatly to the reduction of greenhouse gas emissions.

2.4. Participation in the Clean Development Mechanism (CDM)

Apart from these climate-related energy policies, China also gets involved in the global climate change regime by its active participation in the Clean Development Mechanism (CDM). With the Kyoto protocol’s entry into force in 2005, China has been actively making use of CDM—an international emission-reduction-credit system offered by the Protocol to produce mutual economic benefits for both the investing and host countries. It is reported that China is by far the largest source of CDM credits, accounting for more than 40% of those generated to date. China even has a larger share (55.38%) in the expected average annual Certified Emission Reductions (CERs) from registered projects by host party (Figure 8, UNFCCC, 2009, up to 21/02/2009)[14]

[14] ‘Percentage of CDM host countries’. 21 February 2009, Available HTTP: http://cdm.unfccc.int/Statistics/Registration/AmountOfReductRegisteredProjPieChart.html (accessed 21 February 2009).

Figure 8: Percentage of Clean Development Mechanism host countries



Source: UNFCCC, as of 21/02/2009

Within the CDM credits already obtained, most of which came from destruction of trifluoromethane (HFC_{23}), representing roughly 90% of all the issued CERs. Other key project types involve the capture of methane from landfills and nitrous oxide (N2O)—both are potent greenhouse gas. An increasing number of renewable energy and energy efficiency projects is getting registered in the past two years and is expected to represent a larger share in China's CDM projects.

It is claimed by some researchers that China's dominance in the carbon trading market is partly due to its entrepreneurship in developing CDM projects and also to its relatively low risk investment environment, compared to other host countries.[15] Indeed, China did spot the commercial opportunity embedded in the CDM and made institutional arrangements to smooth the way for its introduction to China. For instance, the central government established the National Coordination Committee on Climate Change in 1998 and clearly stipulated it as the review and coordination agency for CDM projects in 2003. An Office of National Coordination Committee on Climate Change was also created as the executive body to deal with CDM issue (located within National Development and Reform Commission).

As early as 2005, National Development and Reform Commission, along with some other ministries, issued *Measures for Operation and Management of Clean Development Mechanism in China*, which provides policy framework as well as detailed instructions for industry to effectively participate in CDM. It is reported that the CDM office has provided clear guidance on eligibility, application and approving procedures, and benefits sharing for registering as a CDM project. And thus potential applicants are better equipped to make a successful registration. The establishment of three carbon trading centers in Beijing, Tianjin and Shanghai in 2008 also provides trading platforms for the carbon credit transactions. All these institutional arrangements have effectively created a friendly investment environment for both overseas investors and domestic enterprises. The CDM project boom then came as no surprise.

Indeed, it is true that the enormous amount of revenues that could be generated from CDM projects is the major motivation for both the Chinese government and private industry. Although the government takes a large share of the revenue (65% in HFC23 projects and 35% in other types of projects), the enterprise's enthusiasm for reaping the windfall profits

[15] 'Climate Change Mitigation Measures in the People's Republic of China', Pew Centre on Global Climate Change.

from CDM projects still remains great. The revenues taken by the government are used to set up an environmental fund that supports energy saving and deployment of renewables. It is noteworthy that the promotion of CDM projects will help enhance the environmental capacity-building and institutional development. For instance, it is imperative for the host country to establish credible emissions baselines so that the reduction credits created under the projects can be reliably measured and verified. In order to realize the mutual benefits of the CDM projects, there is every reason to expect China and the investing countries to exert real efforts to meet the baseline-setting standards.

However, there also exist barriers for the development of CDM in China. For instance, it took a long time for the Executive Board (EB) to pass a methodology for assessing a new type of CDM projects. Therefore, only a small number of CDM projects that registered with NDRC could eventually be approved by the Executive Board and create financial benefits for the host enterprises. Most other registered projects will be refused and have no way to recover their financial costs—which are not always small. How to ensure enterprises are not intimidated by the potential loss of their initial investments still remains an issue unsolved. In addition, since most applicants in China normally lack expertise to participate in CDM, they are often placed in a disadvantageous position when negotiating with foreign investors who are usually better equipped with relevant knowledge. As a result, the contract price for Certified Emission Reductions (CERs) tends to be relatively low and core mitigation technology transfer rarely takes place (Teng, etc. 2008).

It should also be noted that there are costs involved in international climate change cooperation and the costs may be huge for China. While the CDM projects generate financial income for both industry and government in a short term, they may exhaust the lowest-cost carbon mitigation options currently available in China. In a long term, China may be left with fewer economically affordable mitigation options when it has to shoulder carbon reduction responsibilities in the future.

Despite the potential risks in CDM, the Chinese government has reiterated its support for the continual application of CDM after 2012 while arguing for more technology transfer from the developed countries (State Council, 2008).

To sum up, China’s greenhouse gas emissions will continue to soar as a result of its economic boom and its continual reliance on coal. Since the adverse effects of climate change are beyond discussion, moderating its greenhouse gas emissions will be a daunting, but laudable task for the Beijing government. The energy efficiency and renewables programs are meaningful but far from adequate. As discussed above, it appears to be impossible, with current or currently developing technologies such as CCS, to produce the 80% reductions in GHG emissions which scientists recommend over the next four decades. What other measures might be feasible for China to make more substantial contributions to global climate-change-mitigation efforts?

Section 3: Relocalization: Some Preliminary Considerations

China’s dilemma is the need to sustain a developing economy which depends crucially on GHG-emitting processes. It appears to be impossible to do this without some radical restructuring of economic activity, since it seems that it cannot be done by some combination of greater energy-efficiency and substituting fossil fuels by renewables or nuclear power. An alternative over the longer term is to promote relocalization of production and exchange using local and regional renewable resources.

One possible definition of relocalization is: the process by which a region, county, city or even neighborhood frees itself from an overdependence on the global economy and invests its own resources to produce a significant portion of the goods, services, food and energy it consumes from its local endowment of financial, natural and human capital

(Talberth et al, 2006). It can be seen that the idea of relocalization covers a wide range of functions and changes, from food supply, transportation, urban planning, to the energy restructuring.

There are many towns and cities in the western world in which groups are planning and beginning to implement such changes. For instance, the Transition Town Initiative, which originates from a small town in England, has now “gone viral” in England and beyond (Hopkins, 2008). The focus of transitioning one’s community centers on rebuilding local resilience which refers to ‘*an ecosystem’s ability to roll with external shocks and attempted enforced changes. In the context of communities and settlements, it refers to their ability to not collapse at first sight of oil or food shortages, and to their ability to respond with adaptability to disturbance*’ (Hopkins, 2008, p.54). The transitioning also aims to address the question: ‘*…for all those aspects of life that this community needs in order to sustain itself and thrive, how do we significantly increase resilience (to mitigate the effects of peak oil) and drastically reduce carbon emissions (to mitigate the effects of climate change’* (Hopkins, 2008, p.56).

It is claimed that the resulting coordinated range of projects across all these aspects of life could lead to a collectively designed *energy descent* pathway which means the transition from a high fossil fuel-use economy to a more frugal one (Odum and Odum, 2001).

Although ‘relocalization’ may not explicitly be put forward as the target, some cities and towns have already established task forces to address climate change issues, sometimes together with other pressing concerns such as energy security and peak oil, assess their vulnerability to the adverse impacts of climate change, and to plan their moves to types of urban economies that minimize the consumption of fossil fuel (Lang and Miao, 2008). Some of these initiatives focus on ‘energy efficiency’ or energy-supply-volatility, and some also explicitly link the problems of global warming and other concerns such as peak-oil, intending to address both by major reductions in the consumption of fossil fuels. These reductions would be achieved by some combination of greater efficiency, better design of buildings and appliances, reduced consumption, and relocalization in the supply of food, goods, and energy. Some cities have produced a lot of local activity, a planned sequence of changes in transportation and regulation, and early support for local food production. No city overseas has come close to achieving a transition to an economy that relocalizes all aspects of life. But many of these cities provide useful models of some of the activities and plans that will be needed.

Of course, the social and ecological conditions in Chinese cities are quite different from most of these overseas communities. Planning must take account of local conditions. The political conditions are also quite different, and civil-society groups have played a major role in many of the overseas ‘transition’ initiatives, while such civil-society groups are much less vigorous in China for a variety of reasons. But there is no doubt that if citizens in China’s cities can be engaged by local government agencies in collaborative discussions about transitions to sustainable urban life, that there are large resources of expertise which can be mobilized for such discussions and planning.

It is particularly notable that many Chinese cities are surrounded by agricultural districts in which agricultural knowledge and skills are still strong. It is crucial to preserve these rural districts, since their food production will be essential in the future for the life of the local cities. It is also important to maximize food production within cities. Again, China’s cities are probably more well-prepared to promote intra-city food production than most overseas cities. But the importance of intra-city food production must be recognized, and plans developed for progressive expansion of such production.

Finally, the transportation systems and the related planning of residential districts, and the question of sustainable populations and population densities in cities, need much more attention from citizens and planners. Cities must not be allowed to sprawl outwards into rural agricultural districts, with accompanying demands for energy-intensive transportation.

In fact, China is almost uniquely well-qualified to take this approach, and indeed, could become a leader in such innovations and such technologies. In the longer term, it is very much in China's national interest to follow this path.

Conclusion:

Climate change is becoming more and more important in China's political agenda. The vulnerability of itself to the adverse impacts of climate change, coupled with the increasing pressure from the international community, will impel Chinese policy makers to take climate change seriously. However, China's GHG emissions will continue to rise rapidly as it will rely heavily on coal, the most carbon-intensive fossil fuel, to engine the economy for a long period of time. And although China is installing more high efficient coal units, a high efficient coal-fired power plant emits twice as much CO2 as that of a gas power plant. The absolute increase of GHG emissions is likely to strain China's development in a coal-constraint world.

Meanwhile, China has improved greatly energy efficiency in the past few years and set up ambitious target of boosting the supply of renewable energies such as hydro, solar, winder and even nuclear power. The Beijing government is trying to reduce China's dependence on fossil fuels, in particular imported oil, by diversifying the energy sources. Whereas climate-change-mitigation is obviously not the concern that bred these energy-oriented policies, they have produced remarkable climate benefits. However, although the development of these programs is encouraging, they are far from adequate given the absolute amount of primary energy that is needed to maintain the high growth rate of China's GDP. Fossil fuel, especially coal, will still remain as the dominate source. In addition, there is no timeframe to put the CCS into large-scale commercial use and the carbon abatement potential of electric car in China is limited as most of the electricity for recharge would come from coal-fired power plants.

It would not be easy for China to address the dilemma of sustaining a developing economy which depends crucially on GHG-emitting processes. Fundamental changes are needed, and relocalization is an interesting option. Many overseas towns and cities have provided various models to reduce their dependence on fossil fuels by relocalizing many aspects of life, including food supply, energy structure, transportation, urban planning, etc. China may not yet have faced the same level of energy problems as those in the developed nations do in many of the regions, and it is uniquely well-positioned to make such transition since many Chinese cities still have intensive agriculture right up to the edges of the cities, and even within some cities. China is also capable of producing innovative designs in urban development and redevelopment to minimize transportation costs and promote much greater energy efficiency. The various kinds of so-called 'eco-cities' initiatives in China, and the growing interest in what has been called the 'circular economy' (recycling, re-using materials and goods, minimizing waste), will contribute to these innovative solutions.

It is a must for China to continue to lift more people out of poverty in a much less carbon-intensive way given the magnitude of the problem of global warming. The Communist Party's political legitimacy also rests upon this. The task to deal with climate change while sustaining economic development is unprecedented; and China is bound to be an important player in making the transition to a low-carbon or zero-carbon economy.

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