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China's Energy Consumption and Opportunities for US-China Cooperation to Address the Effects of China's Energy Use

Introduction

Chairman Bartholomew, members of the Commission, I thank you for the opportunity to discuss with you the effects of China's rapid growth in energy consumption and the consequent growth in local and global pollution – the effects on China's economy and their people and the effects on the US.

I am an economist working on productivity, energy use and environmental policy, recently co-authoring a book on *Information Technology and the American Growth Resurgence*.[1] For the last 12 years I have been working with the Harvard University Center for the Environment, China Project. As the economist in that multi-disciplinary group I write about Chinese economic growth, energy use, local pollution, and CO2 emissions. The main result of our work is a recent book titled *Clearing the Air*.[2] I hope to offer some research results that might be useful for your deliberations.

Let me start by stating some facts that are well known but bear repeating and putting in context.

1) Despite many years of rapid economic growth China is still a poor country, the per capita income in 2005 is $6800, in what World Bank accountants call "purchasing-power-parity terms"[3]. This is to be compared to Thailand's 8700, Mexico's 10800, and Korea's 22000.
2) Poor people use less of everything including energy. In 2000 Chinese energy use per capita is 1/12 that of the U.S., and about 1/6 that of Japan[4].
3) Poor countries, in particular, have few cars per person, and thus in China oil only constitute 23% of commercial energy consumption (in 2004) with coal accounting for 68%. This may be compared to, say, a rich country like the U.S. where coal is only 23%. This means that the air pollution per unit of energy use, even after accounting for differences in pollution control efforts, is much higher in China.
4) While the fossil fuel use per person is not high the emissions from their combustion is not well controlled, despite major advances over the years. This result in much higher emissions of many pollutants compared to the richer countries. High emissions per person combined with high population densities mean exposures to high levels of pollution concentration for many people.

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[1] Jorgenson, Dale, Mun S. Ho and Kevin Stiroh (2005), *Information Technology and the American Growth Resurgence*, MIT Press, Cambridge, MA.
[2] Ho, Mun S. and Chris P. Nielsen (eds.) (2007) *Clearing the Air: The Health and Economic Damages of Air Pollution in China*, MIT Press, Cambridge, MA.
[3] World Bank (2007) World Development Indicators.
[4] Ho and Nielsen (2007) pg 9.

5) Over the past 2 decades advances in pollution control have lowered emissions of particulate matter, but those of sulfur dioxide have not fallen, and those of nitrogen oxides from vehicles have risen. The result is concentration levels that exceed China's own health standards in many parts of the country. Our own, somewhat conservative estimate, put the annual premature mortality due to outdoor air pollution at about 100,000 cases per year. Alternative assumptions generate estimates twice as high.
6) Surveys in China have indicated a high willingness to pay to reduce health damages, valuations comparable to those found in surveys in rich countries. Applying such valuations would put the health damages at an enormous 2-4% of GDP.
7) The trend in energy conservation over time since the reforms in 1978 has been remarkable but seems to have slowed in last few years (see Fig. 1). In the ten years before 1997, energy use per unit of GDP has fallen by 38% according to the official Chinese data, or 4.7% per year. Since 1997 (to 2005) it has fallen by only 2.5% per year, and the outlook for the medium term is for rapidly rising energy use for automobiles. We should note that this historical record is a remarkable performance in comparison to other countries, for example, in the US energy use per unit of GDP has been falling at only 1.7% per year over the last 20 years (although that has accelerated a bit over the last 10 years to 2.3%).
8) These trends and high damages have pushed the Chinese government to put pollution reduction high on their agenda that have been dominated by trying to sustain high economic growth. Combined with energy security concerns this has also put energy efficiency high on the 11th Five Year Plan agenda.
9) This high profile concern, combined with the U.S. interest in reducing trans-boundary pollution and greenhouse gas emissions, makes this an important time to develop U.S. policies to sustain these energy efficiency and pollution control efforts. These efforts are linked to the trade flows between the two countries, an issue of great concern to the U.S. In this context, the Strategic Economic Dialogue of Treasury Secretary Paulson is hugely important.

Energy Use and Air Pollution

Fossil fuel combustion generates particulate matter (PM), sulfur dioxide, nitrogen oxides and other toxic substances. SO2 and NOx turn into acid rain, and form ozone and particulate matter (sulfates and nitrates). In big smoke stacks PM may be removed by scrubbers or electrostatic precipitators, and SO2 is dealt with by desulfurization (FGD) systems. The former has been installed in many power plants and other industries over the years leading to a sharp decline in PM emissions despite the rising coal use (17.4 million tons of PM in 1995 to 10.5 mil. tons in 2003 while coal use rose 22%).

SO2 emissions has fallen a little in the 1990s but rose again in the 2000s, as the new FGD units barely kept pace with the rise in coal use. SO2 emissions were 23.7 million tons in 1995 and 25.5 mil in 2005 (Fig. 3). The most dismal trend is nitrogen oxides which is rising rapidly with the growth of motor vehicles, doubling between 1990 and 2004. In that period oil use rose by 7.3% per year.

A small positive recent trend is the rising use of natural gas to replace coal for home heating and cooking (Fig. 2). The share of natural gas in total energy rose from 1.8% in 1995 to 2.9% in 2005. And with the completion of the gas pipeline to Shanghai, and more liquefied natural gas terminals, we should see a greater substitution soon. The use of gas will, however, remain low for a long time, in sharp contrast to the US gas share of 23%.[5] This means that indoor air pollution from coal stoves will continue to be a major problem for some time to come.

Damages due to Air Pollution

Fine particulate matter (primary PM, and secondary sulfates and nitrates), sulfur dioxide and ozone have been found to cause premature mortality, chronic bronchitis and other respiratory problems. Acid rain and ozone damage the eco-system and agriculture. The estimation of these damages from epidemiological studies is difficult but there have been quite a few recent efforts, in part supported by experts and funding from the U.S.

Our own conservative estimate using these studies put the number of cases of premature mortality at 94,000 and 1.4 million cases of chronic bronchitis, and 1.3 billion work-days lost. Other estimates put the death risk twice as high. This is not only a lot of personal suffering, but also reduces the ability of people to work, i.e. hurting economic activity.

Policy makers often want to put a dollar number on these damages, in part to compare to the cost of reducing pollution. While this valuation exercise is difficult, and controversial, I believe it is important. Various surveys have now been conducted on people's willingness to pay to avoid health risks in China. (Such survey methods are used, for example, by the US EPA to estimate the costs and benefits of environmental regulation.) These surveys have indicated a high valuation for avoiding health damage and risk.[6] Our own conservative reading of this risk valuation put the value of air pollution damages at 1.8% of GDP. Alternative estimates range as high as 4%, and this does not even include indoor air pollution. A more extensive World Bank study under progress puts the damages from air pollution at 1.2-3.8% of GDP.[7]

Global effects of Chinese Emissions

In addition to this local pollution there are regional and global effects. The acid rain due to Chinese coal burning reaches Korea and Japan. Mercury from coal burning may travel as far as California.

[5] These figures are from Chap. 1 of Ho and Nielsen (2007), World Bank (2007), China Statistical Yearbook 2006, and the EIA's *Annual Energy Review*.

[6] Ho and Nielsen (2007) Chapter 8, and Chapter 4 in World Bank (2007b) *Cost of Pollution in China: Economic Estimates of Physical Damages*, Washington, DC. The US surveys indicate a "value of statistical life" at $5-8 million, or about 120-200 times per capita GDP. The Chinese surveys indicate a ratio of 50-150 times per capita GDP.

[7] World Bank (2007b).

Another related issue is greenhouse gas emissions and climate change. The burning of fossil fuels generate carbon dioxide, and China will soon be the largest source of such CO2, overtaking the U.S. (In the mid-2000s the US generated 21% of the world's CO2 from fossil fuels, China 15%.) In the short run the efforts to reduce local pollution through the use of desulfurization systems will increase electricity use, i.e. raise carbon emissions. However, in the longer term the efforts must include improvements in energy efficiency and fuel switching. These will reduce carbon emissions.

Policies to Limit Emissions

Given the nature and scale of the problem China is urgently developing policies to both increase energy efficiency and reduce emissions. Historically, in the rich countries, the approach has been to require the use of certain control technologies and imposing emission standards. These policies have a place in the policy toolbox, but we should also be thinking of alternatives, in particular policies that harness market forces. In the U.S., for example, electrostatic precipitators have long be required, however, for the case of SO2 in electric utilities a "cap and trade" system has been in place for a while now showing quite good results. That is, instead of requiring each plant to install FGD systems, utilities may choose any method to reduce SO2 emissions including buying emission rights from other companies which can reduce them more cheaply. This has led to the use of lower sulfur coal and other innovations.

To continue this example, in the current 11th 5-year plan covering 2006-2010, the Chinese government envisages requiring all new power plants to immediately install FGD, and existing plants to rapidly upgrade existing desulfurization systems. These systems use about 2% of the electricity generated, i.e. the gross revenues of the utility is reduced by about 2% as a result of this rule. This is a large incentive to cheat and turn off the pollution control equipment. Local Environmental Bureau officials may be unable to detect this, or may be ordered to ignore it by corrupt senior officials.

This example serves to highlight two points. One, flexible policies that allow emitters to choose the least cost way of reducing pollution would generate higher rates of compliance, not to mention make sense economically. Two, systems must be put in place to properly monitor emissions to avoid cheating.

Green Tax Policies

In this spirit of examining alternatives to end-of-pipe regulations we have examined policies that try to make producers and consumers face the true cost of fuel use, policies that implement the "polluter pay" principle. Pollution is a "negative externality," i.e. the factory owner does not bear the cost of the health and material damages mentioned above. The customers of the factory thus also do not pay for the damage in their purchase decision, they pay when they suffer the health damages.

A pollution tax would "internalize" this externality, if producers are charged a fee for every ton of SO2 they produce, then they would: (a) find ways to reduce SO2 emission, (b) raise the price of their output leading consumers to use less of this environmentally-unfriendly good, leading to lower output and lower fuel use. The level of the fee should thus be set in a manner that balances these costs on producers and consumers with the health benefits.

Such a system of sulfur taxes, or pollution fees generally, is feasible in cases such as the electric utility emissions, however, there are many small sources of pollution where it is costly, or plain impossible, to monitor the emissions. We, therefore, first consider an alternative that taxes output based on the air pollution damages that it causes. This essentially means a high tax on electricity, cement, metals and chemicals. We find that such a system would discourage consumption of dirty goods a little, leading to a modest fall in pollution. Such a tax leads to substantial revenues for the government and may be useful in that regard but is not an effective pollution reduction tool.[8]

Another alternative policy we examined is a tax on fuels, in proportion to the damage caused. This amounts to a heavy tax on coal and a lighter tax on oil. Such a policy induces (a) energy conservation, (b) fuel switching, (c) higher prices of energy intensive products. This results in a large fall of coal use and pollution, a switch to less energy intensive goods and higher net imports of energy intensive goods. GDP falls modestly as a result.[9] Such an outcome also means shutting down coal mines and thus requires adjustment assistance; however, the overall benefit-cost balance is clearly positive even from a purely Chinese national perspective.

Role of US in promoting pollution reduction in China in the context of overall US-China relations

However, such a policy which reduces fuel consumption also mean substantially lower trans-boundary pollution and lower greenhouse gas emissions, a global benefit. It is true that a system of purely national pollution taxes would result in higher imports of dirty goods, meaning that there is offsetting higher emissions in the rest-of-the-world. Even accounting for such "leakage" the overall net benefits, national or global, is a large positive number. It is thus in the interests of the international community to help ensure the successful implementation of such a policy.

How can the U.S. contribute to such an outcome? I.e. the successful implementation of policies targeted primarily to reducing domestic Chinese air pollution and improving energy efficiency, but which also have this positive global externality.

- At the simplest level, intensify current capacity building efforts to expand the analytical capabilities to perform cost-benefit research. Understanding the magnitude of benefits of pollution control is key to getting policy makers at all

[8] Analysis by Ho and Jorgenson in Table 10.3 in Chapter 10 of Ho and Nielsen (2007).
[9] Ho and Nielsen (2007) Table 10.6.

levels of government to devise and implement control policies. Knowledge of the costs are important too although they are usually quite a bit more transparent (e.g. the costs of building and operating scrubbers). Such capacity building is already being promoted by the US EPA, DOE and private foundations, in addition to the efforts of other governments.

- In the same vein, sharing knowledge gleaned from US energy efficiency efforts, e.g. energy-efficient buildings and homes, energy-efficiency ratings for appliances and vehicles. Sharing knowledge of monitoring procedures and equipment; as noted above, a key element for success is monitoring to prevent cheating. This requires the operation of sophisticated automated monitoring systems and inspection systems.
- Investment in control equipment and advanced high-efficiency technologies is complicated by two issues – costs and intellectual property rights. As noted by the FGD example above, the cost of installing and operating control equipment was a serious barrier to its adoption; it still is, although as the people's incomes rise the ability to pay for cleaner electricity rises. Secondly, selling high-tech equipment by the advanced countries to China in the past has been made difficult by the Chinese insistence on promoting domestic capacity on one hand, and the concerns by the sellers for their intellectual property rights on the other. These issues should be re-visited, perhaps as part of an international discussion of global environmental concerns and economic relations.
- Investment in infrastructure such as public transportation systems is a very expensive undertaking normally undertaken when societies are much richer than China's current level. The international community should be motivated to help finance such long term investments that bring immediate benefits in the form of reduced energy use, reduced pollution and congestion. A higher rate of investment would likely mean a lower trade surplus.

The last two points form natural topics for Secretary Paulson's Strategic Economic Dialogue. The US and international community should make the following argument: (a) China is now able to afford basic control equipment, both from the point of view of the up-front capital costs, and the higher operating costs. These costs would be reflected in higher electricity, steel and cement prices, but as shown by the expressed willingness to pay for a cleaner environment, they would be seen as a worthwhile tradeoff by the people.

(b) China as an economy in transition has many rigidities in its goods and credit markets, and this has led to patterns of savings and investment, and domestic use versus export that are far from optimal. A poor country (i.e. one with fewer infrastructure and equipment) would normally be borrowing to finance capital spending, and then repaying over the longer term. This is much like a young family borrowing to buy a house and repaying over its working life. This has been the case during the 1990s when China ran current account deficits, but is no longer so with the large surpluses. Some of this is due to investment bottlenecks (capacity constraints in ports and transportation), but some due to the poorly developed capital markets, and the government's control of the major state enterprises such as electric utilities. Reducing these rigidities and constraints, and investing in public infrastructure should be a priority.

The challenges are thus (a) to convince the policy makers that it is in China's own interest to pursue a policy of investment in pollution control and energy efficiency, even one which requires importation of foreign technology on terms that protect intellectual property rights; (b) to convince all levels of government that costly investment in mass transit and sewerage systems bring immediate environmental benefits as well as being in line with international trade objectives; (c) to convince US policy makers to expand efforts to assist the Chinese in building up capacity for devising and implementing pollution and energy efficiency policies.

Fig 1. Energy consumption per unit GDP (1980=1)

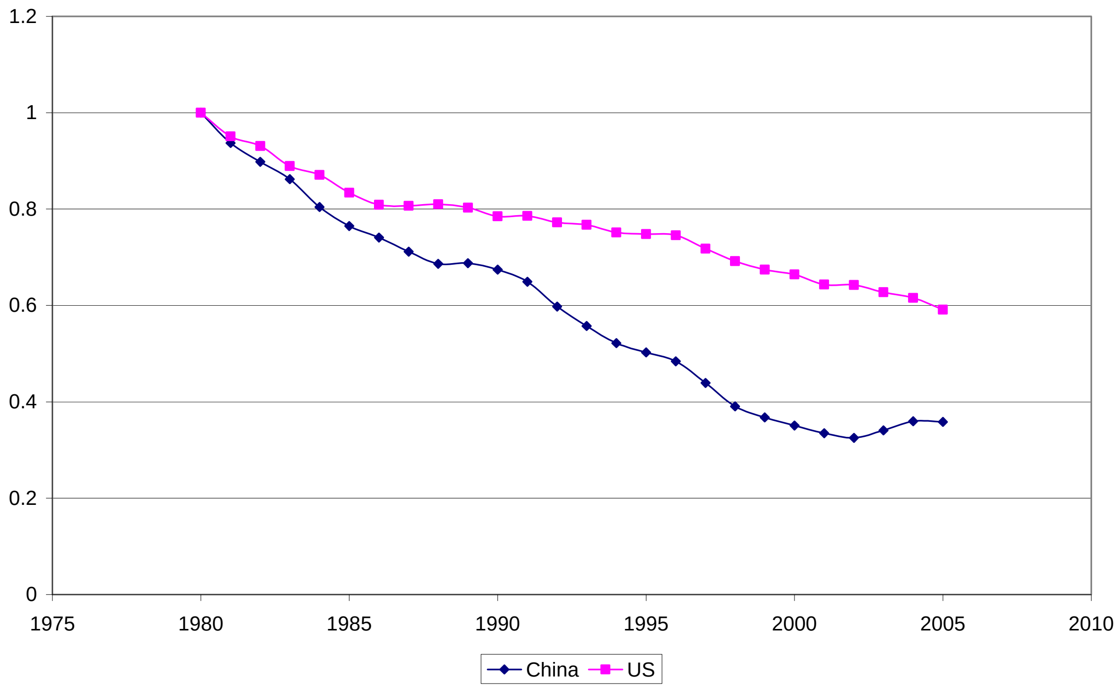
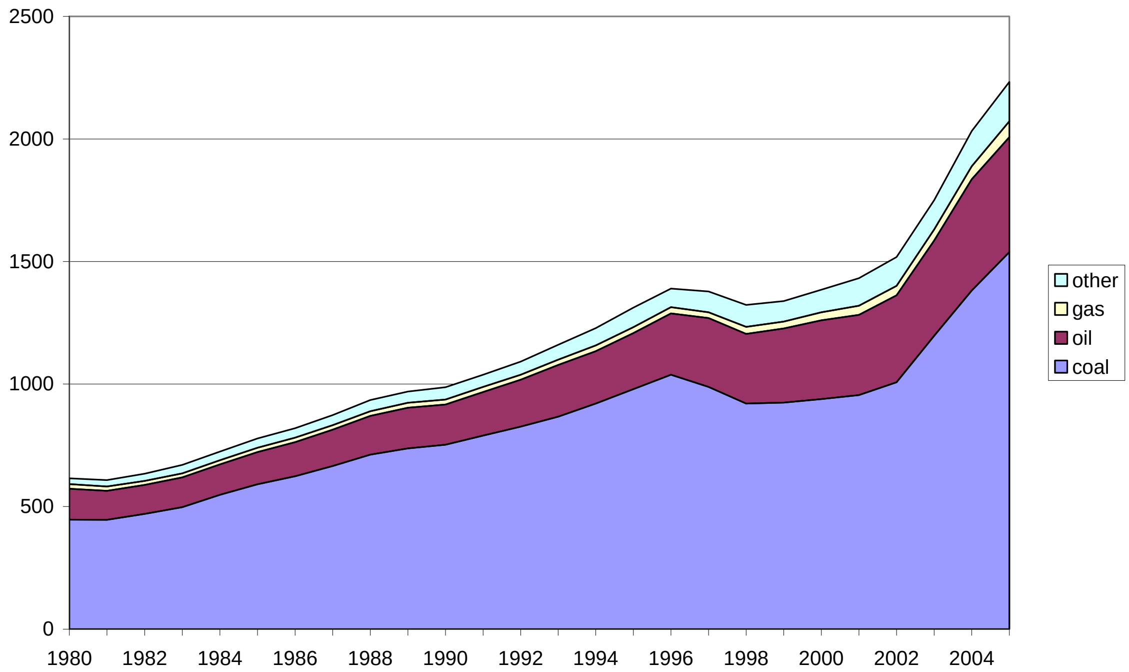
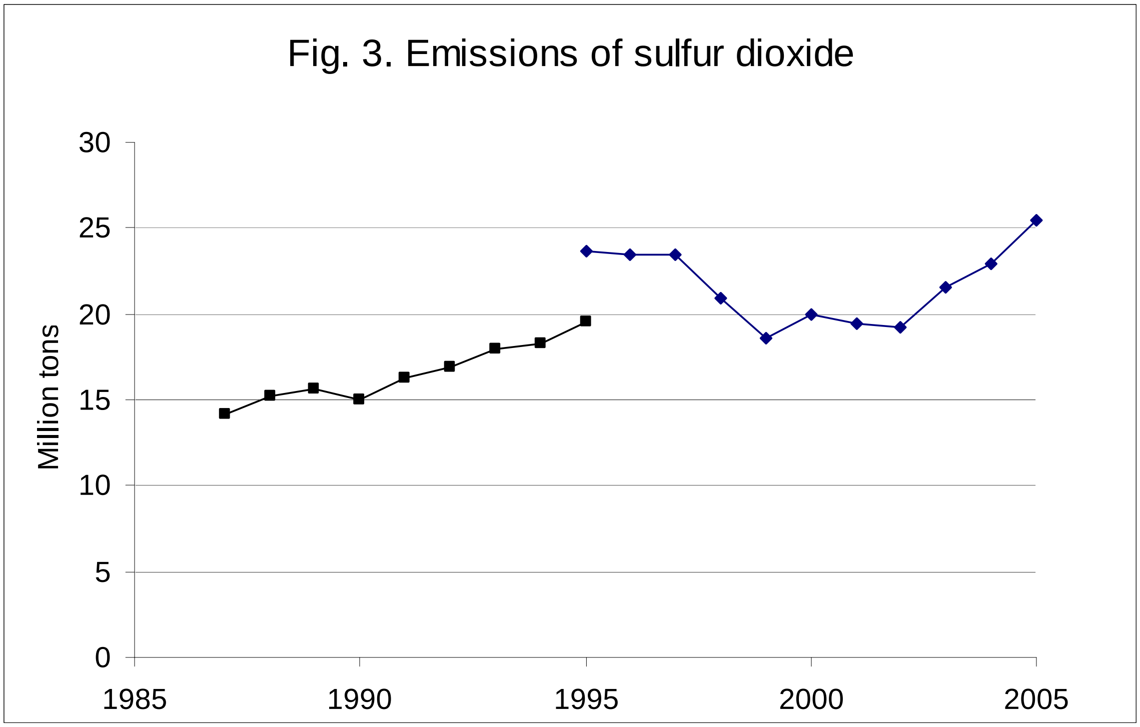


Fig. 2. China Primary energy consumption (mil. tce)





Note: Change in scope of coverage in 1995.