

Asia Policy Perspectives

China's Energy and Environmental Problems and Policies

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Abstract

This paper describes China's energy and environmental degradation problems in terms of air pollution, water pollution, CO₂ emission and shortage of energy. It discusses the laws, agencies established and policies introduced to solve the energy-environment problems as well as the practical difficulties in the implementation of government environmental policies. Finally it presents two proposals to improve the protection of China's environment.

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1. Introduction

The economic activities of production and consumption require the use of energy, and the use of energy affects the environment in the forms of water pollution, air pollution and emission of CO₂ that causes global warming. Furthermore, the use of energy from exhaustible resources could result in an energy shortage in the future. The solutions to the problems of energy and environmental degradation include (1) reducing the use of energy in production and consumption, (2) increasing the use of energy-saving and environmentally friendly methods in production and consumption and (3) promoting technological innovations that will reduce the use of energy per unit of output (reduce energy intensity or increase energy efficiency) or reduce pollution per unit of output to achieve (1) and (2) in the future. To achieve (1) and (2), given the state of technology, we can regulate the use of energy by law or by economic incentives to limit the emission of pollutants.

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The last is an example of solving the problem of “externalities” in economics – the undesirable external effects of production or consumption, the cost of which is not borne by the producer or consumer responsible. An economic solution to the problem of externalities is to charge the cost to the producer or consumer who is responsible for polluting the environment in this case.

In section 2, I describe the energy-environment problems during China’s recent economic development. In section 3, I discuss the laws, government agencies established and the policies introduced by the Chinese government to protect the environment and reduce energy consumption. Section 4 deals with difficulties in implementing China’s environmental policies. Section 5 presents two proposals to improve the protection of China’s environment. Section 6 concludes.

2. Environmental Problems in China

As pointed out in the Introduction, there are four aspects of the energy-environment problem, namely, (1) air pollution, (2) water pollution, (3) the emission of CO₂ into the atmosphere that causes global warming, mainly from the burning of coal, and (4) shortage of future energy supply that relies on exhaustible resources. Environmental pollution from coal combustion is damaging human health, air and water quality, agriculture and ultimately the economy. China is facing all four problems.

2.1 Air Pollution

The air and water in China, especially in the urban areas, are among the most polluted in the world. According to a report of the World Health Organization (WHO) in 1998, of the 10 most polluted cities in the world, seven can be found in China. Sulfur dioxide and soot caused by coal combustion are two major air pollutants, resulting in the formation of acid rain, which now falls on about 30% of China’s total land area. Industrial boilers and furnaces consume almost half of China’s coal and are the largest sources of urban air pollution. The burning of coal for cooking and heating in many cities accounts for the rest.

Another major source of air pollution is the use of oil and gasoline in the transportation sector, especially the emission from automobiles and jet engines. As the country becomes industrialized, pollution from both industrial and consumer sources will increase because of higher levels of output and consumption, the latter including the increase in the use of automobiles and in air travel, unless pollution per unit of output or consumption can be reduced.

2.2 Water Pollution

Mercury released into the air by coal-fired power plants is captured by raindrops, and transferred to the soil, surface water and groundwater. Surface water affects the fish consumed. Groundwater is polluted by runoff from factories, smelters and mining operations, and then used by farmers downstream to irrigate their crops. Heavy use of

fertilizers has contributed to contamination also. Fertilizers in China often contain high levels of metals, especially cadmium, which is harmful.

China's water is polluted also by the disposal of waste. There have been large quantities of deposits of organic and toxic waste from households, agriculture and industry.

Deforestation has caused the flow of mud along the rivers and affects water supply and quality. *People's Daily*, June 12, 2007 reports that Lake Taihu was covered with a foul-smelling algae and freshwater was shut off for more than two million people in Wuxi due to the blue-algae infestation of the lake.

Besides the poor quality of water there is the problem of the shortage of water. Water beds of several important cities including Beijing and Shanghai are low, causing a shortage of supply of well water. Supply of water from rivers including the Yellow River and the Yangtze River are running short because of diversion to agriculture production and electricity generation along the sources.

2.3 Energy Consumption

According to the "China Country Analysis Brief" published by the US Department of Energy (2001) China accounted for 9.8% of world energy consumption. By 2025, projections indicate that China will be responsible for approximately 14.2% of world energy consumption. Of the 40 quadrillion Btu of total primary energy consumed in China in 2001, 63% was coal, 26% was oil, 7% hydroelectricity, and 3% natural gas. While residential consumption has increased its share of China's energy demand over the last decade, the largest absolute gains in consumption were from the industrial sector. In 2001, China's energy intensity as measured by thousand Btu per 1,990 US dollars of output was as high as 36,000, as compared with 21,000 for Indonesia, 13,000 for South Korea, 4,000 for Japan and 11,000 for the United States, because of differences in output mix among these countries and in energy intensities in producing the same products.

While China ranks second in the world behind the United States in *total* energy consumption and carbon emissions, its *per capita* energy consumption and carbon emissions are much lower than the world average. In 2001, the United States had a per capita energy consumption of 341.8 million Btu, greater than 5.2 times the world's per capita energy consumption and slightly over 11 times China's per capita consumption. Per capita carbon emissions are similar to energy consumption patterns, with the United States emitting 5.5 metric tons of carbon per person, the world on average 1.1 metric tons, and China 0.6 metric tons of carbon per person. With a growing economy and increasing living standards, however, per capita energy use and carbon emissions are expected to rise. Although per capita energy use is relatively low, China's total consumption of energy and the resultant carbon emissions are substantial, due to the country's large population and heavy use of coal.

Concerning the possible shortage of future energy source, China imported 162.81 million tons of oil in 2006 as the world's second largest energy user. Its dependence on imported oil reached 47%, having increased by 4.1 percentage points from 2005. China's rapid increase in oil consumption will contribute to future shortage of this exhaustible resource.

2.4 CO₂ Emission

CO₂ emissions result in climate changes which are affecting the world's physical and biological systems. As of 2001 China accounted for 13%, Western Europe 16% and the US 24% of the world's energy related carbon emission. By 2007 China has taken over the US for the first time as the world's top producer of greenhouse gases. China is a non-Annex I country under the United Nations Framework Convention on Climate Change. This means that it has not agreed to binding emissions reductions in the Kyoto Protocol, which it ratified in August 2002. China's policies aim at cutting energy costs and reducing local pollution, rather than reducing carbon emissions for the benefit of the world.

People's Daily Online (June 4, 2007) reports the following facts:

“According to the Initial National Communication on Climate Change of the People's Republic of China, the country's total greenhouse gas (GHG) emissions in 1994 are 4,060 million tons of carbon dioxide equivalent... Its total GHG emissions in 2004 is about 6,100 carbon dioxide equivalent, of which 5,050 million tons is carbon dioxide, 720 million is carbon dioxide equivalent of methane and 330 million is carbon dioxide equivalent of nitrous oxide. From 1994 to 2004, the average annual growth rate of GHG emissions is around 4%, and the share of carbon dioxide in total GHG emissions increased from 76% to 83%.

“China's cumulative emissions of carbon dioxide from fossil fuel combustion accounted for only 9.33% of the world total during the period of 1959-2002, and the cumulative carbon dioxide emissions per capita are 61.7 tons over the same period, ranking the 92nd in the world.

“Statistics from the International Energy Agency (IEA) indicate that per capita carbon dioxide emissions from fossil fuel combustion were 3.65 tons in 2004 in China, equivalent to only 87% of the world average and 33% of the level of the Organization for Economic Co-operation and development (OECD) countries.

“Along with steady social and economic development, the emission intensity defined as the carbon dioxide emission per unit of GDP declined generally. According to the IEA, China's emission intensity fell to 2.76 kg carbon dioxide per U.S. dollar (at 1999 prices) in 2004, as compared to 5.47 kg carbon dioxide per U.S. dollar in 1990, a 49.5% decrease. For the same period, emission intensity of the world average dropped only 12.6% and of the OECD countries dropped 16.1%.”

Since China is a developing country, it is not surprising that its per capita CO₂ emission was only 87% of the world average and 33% of the level of the OECD countries. The concern is the rate of increase in China's per capita CO₂ emission.

There is a consensus in the scientific community that the level of total CO₂ in the atmosphere should not exceed a level equal to twice the level existing before the

Industrial Revolution (Pacala and Socolow, 2004). Exceeding that level could cause violently unstable weather, melting glaciers and prolonged draughts. If the rate of increase in emission in the future continues as it did in the last 30 years, this critical level could be reached in 50 years' time. Therefore CO₂ emission is a critical and urgent problem. To obtain a global agreement on this issue is difficult, as shown by a week-long meeting of the Intergovernmental Panel on Climate Change in Bangkok, reported in an article in *San Francisco Chronicle* on May 7, 2007.

For China to be willing to reduce its use of coal-fired power plants that cause CO₂ emission alternative energy source must be priced not higher than the price of power generated by coal. This will be possible if there shall be sufficient technological innovations in the production of clean energy at such low prices. Market incentives for such innovations have a good chance of success, according to Friedman (2007: 50).

Without the benefit of new technology, the world community can reduce the rate of increase of carbon emission by (1) using alternative sources of energy to coal such as gas, nuclear, ethanol and solar, (2) reducing the consumption of electricity in homes, offices and factories, and (3) controlling the amount of CO₂ emission by reducing the burning of forests and capturing the amount of carbon from coal burning.

3. Laws, Agencies and Policies for Protecting the Environment

3.1 Laws and Agencies for Environmental Protection

The Chinese central government is aware of the environmental problems and has made serious attempts to protect and improve China's environment. In 1979, China passed the Environmental Protection Law for Trial Implementation. The 1982 Constitution included important environmental protection provisions. Article 26 of the Constitution requires that "the state protects and improves the environment in which people live and the ecological environment. It prevents and controls pollution and other public hazards." There are also provisions on the state's duty to conserve natural resources and wildlife. Based on these provisions a number of special laws have been enacted. These include the Water Pollution Prevention and Control Law of 1984, the Air Pollution Prevention and Control Law of 1987, the Water and Soil Conservation Law of 1991, the Solid Waste Law of 1995, the Energy Conservation Law of 1997 and several important international agreements including the Kyoto and Montreal Protocols. Beginning in the late 1980s, Premier Li Peng, a nuclear engineer by training, issued statements underscoring the government's commitment to giving attention to environmental protection in its formulation and implementation of economic development policy. China's national legislature, through its promotion of "Cleaner Production" and other attempts to reduce air pollution, has significantly revised the Law on the Prevention and Control of Air Pollution in 2002.

New laws establishing comprehensive regulations have begun to curb the environmental damage. On the national level, policies are formulated by the State Environmental Protection Administration (SEPA) and approved by the State Council. The role of SEPA, which was established in 1998, is to disseminate national environmental policy and regulations, collect data and provide technological advice on both national and international environmental issues. In June 2002, China enacted

the Cleaner Production Promotion Law, which established demonstration programs for pollution regulation in 10 major Chinese cities, and designated several river valleys as priority areas. So far the laws are mainly of the regulation and control variety, rather than market-based policies such as taxing the polluters, partly because the government has not been able to design a set of appropriate market-based policies, e.g. to estimate the appropriate tax rate (more on this point in section 3.3).

3.2 Policies for Energy Saving

On Friday, May 8, 2007, Premier Wen Jiabao made a speech stating that the current macro-control policy must focus on energy conservation and emission reduction in order to develop the economy while protecting the environment. The Chinese government has set a target of reducing energy consumption for every 10,000 yuan (US\$1,298) of GDP by 20% by 2010 (or 4% per year), while pollutant discharge (presumably measured by an index of quantities of different pollutants) should drop by 10%.

“To curb excessive growth of the sectors that consume too much energy and cause serious pollution, China must tighten land use and credit supply and set stricter market access and environmental standards for new projects amid efforts to rein in the rapid expansion of energy-gorging industries including power, steel, oil refinery, chemicals, construction materials, and metals.

“Restrictions should be imposed on exports in these sectors as soon as possible... We will continue to curb the energy-guzzlers by further adjusting exports rebates, levying more exports tariff, and reducing exports quotas... China will cancel preferential policies on the industries like lower tax, electricity and land costs.

“Outmoded production methods must be eliminated at a faster pace and how this policy is implemented by local governments and enterprises will be open to the public and subject to social supervision ... The ten nationwide energy saving programs, such as developing oil alternatives, upgrading coal-fired boilers and saving energy indoors, will save China 240 million tons of coal equivalent during the 2006-10 period, including 50 million tons this year...”

Note that Premier Wen’s policy statements for environmental protection include (1) restricting the quantities of outputs, especially those that are environmentally polluting and high-energy consuming, by tightening land use and credit supply, (2) setting environmental standards for production, especially in new projects, and (3) improving method of production to make it environmentally friendly. Category (1) includes the restriction of export production that affects the environment by means of “adjusting exports rebates, levying more exports tariff, and reducing exports quotas.”

3.3. Policies for Environment Protection by Regulation and Economic Incentives

China has set up a system for monitoring the discharge of pollutants but it is far from perfect because it relies on local government officials to implement the system. We will

discuss the difficulties of implementing environmental policies in section 4. For now we continue to examine the polices for environmental protection introduced, given the monitoring system, however imperfect.

To reduce the amount of sulfur dioxide emitted from the burning of coal in the factories, the Chinese government has imposed heavy penalties on such emissions and encouraged the building of equipment to capture sulfur dioxide. However, the use of such equipment is costly even after it is built and many factories do not use it except when they are being inspected. More recently the government is trying to introduce the use of monitoring devices to measure the amount of sulfur dioxide emission coming out of each plant, but such a monitoring system has not yet been put into practice effectively.

China is also using economic incentives to solve the problem of externalities resulting from the use of energy. To reduce the use of coal and encourage a switch to cleaner burning fuels, the government has introduced a tax on high-sulfur coals. A system of emissions trading for sulfur dioxide, similar to that used in the United States, is being tested in some cites with pilot projects, and may eventually be applied nationwide. The Chinese government will advance reforms in the pricing of natural gas, water and other resources, raise the tax levied on pollutant discharge, establish a “polluter pays” system and severely punish those who violate the environmental protection laws. To ensure that fees charged on pollutants are higher than abatement costs and to strengthen existing laws, the government is considering the imposition of large fines on pollutant emissions. The rationale for charging higher fees than the abatement cost may be the expected imperfect enforcement. Potential polluters will equate the expected fine (equal to the fee charged times the probability of getting caught) with the benefit of abatement. Future Chinese environmental initiatives also may include formulating a tax structure beneficial to environmental protection, and granting preferential loans and subsidies to enterprises that construct and operate pollution treatment facilities. The government will also provide incentives to companies that use more energy efficient production facilities and techniques.

Besides economic incentives, efforts are made to introduce technologies that will treat wastewater, prevent air pollution and improve environmental monitoring systems. Because of the above mentioned government policies state and non-state enterprises have tried to find cleaner technology to generate power than from coal. Governments of cities like Shanghai have tried to adopt urban planning strategies that are friendly to the environment. Space within a city is reserved for planting trees in order to improve air quality. Travelers to Beijing, Shanghai and Guangzhou in 1998 to 2000 could see that these cities became cleaner and the air quality was improved during this period.

3.4 Policies on CO₂ Emission

Policies for reducing the emission of CO₂ per se are still under negotiation among nations. China appears to be more concerned with the problems of air and water pollution since the CO₂ emission problem is less urgent for China. A recent expression of China’s policy of limited involvement in the prevention of global warming is a statement of President Hu Jintao on Thursday June 7, 2007, during the G8 meetings in Germany that calls for upholding the principle of “common but differentiated responsibilities”

for developing countries in tackling climate change. “We should work together to make sure the international community upholds the goals and framework established in the United Nations Framework Convention on Climate Change and its Kyoto Protocol [in 1997] and the principle of common but differentiated responsibilities” while developing countries should also carry out “active, practical and effective cooperation... Considering both historical responsibility and current capability, developed countries should take the lead in reducing carbon emission and help developing countries ease and adapt to climate change... For developing countries, achieving economic growth and improving the lives of our people are top priorities. At the same time, we also need to make every effort to pursue sustainable development in accordance with our national conditions.”

Climate change, which could cause rising sea levels and climate swings, was a major issue at the G8 summit from June 6 to June 8, 2007. The Kyoto Protocol, which requires industrialized countries to cut greenhouse gas emissions by 5% from 1990 levels, will expire in 2012. Parties concerned hope to launch negotiations for its replacement at an early date. Skepticism, however, was evident at the summit for reaching a fixed, quantifiable targets for reducing the greenhouse gas emission (*People's Daily Online*, June 8, 2007).

In the meantime, a multinational effort needs to be made to limit the emission of CO₂. As pointed out previously, if the level of carbon dioxide reaches twice the pre-Industrial Revolution level, great climate instability will occur. How to achieve an international political consensus to reduce the rate of increase with each country taking its fair share so as not to exceed the above critical level is a most pressing problem today, but the solution to this problem is beyond the scope of this paper. It suffices to note that China has some incentives to reduce emissions as it receives benefits from the Clean Development Mechanism (CDM), an arrangement under the Kyoto Protocol that allows industrialized countries with a greenhouse gas reduction commitment (called Annex 1 countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries.

3.5 Development of Clean and Renewable Energy

China regards the creation of clean and renewable energy as an important national policy, and is developing hydropower, solar power, wind power, natural gas, biomass fuel and methane under its 11th Five-Year Plan. Current efforts to offset coal consumption include the development of natural gas and coal-bed methane infrastructure, increasing the number of combined heat and power plants, adding approximately 3,000 megawatts (MW) of hydropower annually, and developing renewable energy resources such as wind and photovoltaics for electricity generation.

For China's electricity generation, renewable sources of energy (including hydroelectricity) accounted for 18.6% in 2001, second to coal. With assistance from the United Nations and the United States, China hopes to embark on a multi-million dollar renewable energy strategy to combat pollution. Wind resources are concentrated in the northern and western regions of China, as well as along the coast, and are suitable for both rural village electrification and large-scale, grid-connected electricity production. The highest wind potential in China lies along the coast and the offshore islands, in

or near many of the major population centers. The next highest wind potential region covers Inner Mongolia and the northern Gansu Province, both of which are home to numerous villages with no access at present to grid-based electricity.

Current utilization of solar energy includes small-scale uses, such as household consumption, television relays and communications, but it is increasing steadily, especially in the number of solar kitchen ranges to substitute for the use of coal.

While solar and wind power provide significant renewable energy potential, China's growth in renewable energy in the next decade will be dominated by hydropower, particularly with completion of the 18.2-gigawatt Three Gorges Dam project in 2009. Although the Three Gorges Dam is seen as both an important source of energy for China's growing electricity consumption needs and a means of taming the Yangtze River, notorious for its disastrous floods, the controversial dam also could prove to be an environmental disaster. Thus far, few attempts have been made to address concerns regarding the accumulation of toxic materials and other pollutants from industrial sites that will be inundated after construction of the dam. Other social costs of the dam and the use of hydro-power in general include displacement of people and impact on fisheries.

By 2025, the share of nuclear power used for China's electricity generation is expected to increase to 4% from current share of a little over 1%. The use of nuclear power can be considered a very promising alternative energy source if the problem of disposing its waste can be properly handled.

4. Problems of Policy Implementation and Law Enforcement

As examples of failure to implementing government environmental policies, consider the policies stated by Premier Wen Jiabao in May 2007 as reported in section 3.2. The quoted speech of Premier Wen states:

“The challenge of reducing energy consumption and greenhouse gas emissions has proved arduous as China's economy grew 11.1% in the first quarter [of 2007] but power consumption surged 14.9% ... Energy consumption as a fraction of GDP fell only 1.23% in 2006, well short of the annual goal of 4% [as stated in the 11th Five-Year Plan of 2006-2010].”

The positive aspect of the above story is that, unlike other developing countries such as India, South Korea and Brazil, China was able to reduce both the amount of energy and carbon consumed per dollar of GDP somewhat over the past two decades. The reduction of energy intensity was made possible by its very high level to begin with, the efforts by the Chinese government to conserve energy, and the adoption of more modern industrial plants and equipment. China's Energy Conservation Law came into effect on January 1, 1998. Further efforts by the government to increase overall energy efficiency have included the reduction of coal and petroleum subsidies. Coal consumption is again rising, however, after declining in the late 1990s, and China's energy intensity increased slightly in 2001. At the same time, the government has promoted a shift towards less

energy intensive services and higher value-added products, as well as encouraged the import of energy intensive products.

The failures in meeting policy targets such as reducing energy intensity by 4% per year are the results partly of the unrealistic nature of the targets and partly of the failure to implement laws and policies by the Chinese government in general, including those intended to protect the environment. Besides the reduction of the use of energy per unit of output, a more important way to protect the environment is to control the emission of pollutants in production that uses the same amount of energy or to use clean energy. Laws to control such emissions are not effectively enforced. Chinese producers violate environmental protection laws to reduce cost of production. More importantly, local government officials do not cooperate in enforcing such laws. It is often to the advantage of local governments to allow polluting to take place illegally in order to promote a higher rate of economic growth, and the central government cannot control them. Local government officials benefit from higher levels of output in their region as they receive credits for economic development and sometimes bribes from polluting producers. These factors will continue to hinder the enforcement of environmental laws for some time to come.

However, there are also factors contributing to the successful implementation of laws and policies to protect the environment. One is the strong resolve of the central government. The National People's Congress enacted on October 28, 2007 a Law on Conserving Energy by stating that work carried out by local government officials in energy conservation should be integrated into the assessment of their political performance along with output growth. The second factor is that, if it wishes, the central or local government has the power to enforce such laws because the operation of an industrial enterprise requires its approval and sometimes even its assistance in the provision of land or credit. In order to protect and improve the environment the government can not only punish the offender but can provide economic incentives for people to act for the economic welfare of the society. There are a number of incentive schemes adopted by the Chinese government for industrial producers as described in section 3.3. Wheeler, Dasgupta and Wang (2003) provided econometric evidence to show that pollution levy does have a negative effect on the quantity of water and air pollution per unit of output. Third, there is a positive income effect on the demand for a clean environment. As the Chinese economy gets more developed the demand for cleaner water and air will increase, and the Chinese people can afford to pay for it. In the long run, though not necessarily in the near future, this favorable income effect should more than offset the unfavorable effect of producing a large quantity of output as the experience of the developed economies has demonstrated.

Since the control of pollution resulting from production using existing technology is difficult, one way of protecting the environment is to promote the use of clean energy by reducing its price relative to the price of existing energy. This can be achieved by imposing a cost on using polluting energy (which is hard to enforce) or by promoting technological innovations for the development of clean energy, especially to replace the use of coal. There are incentives in the free market for such innovations to take place. In addition the government can promote such innovations by subsidy and tax policies if it can identify them correctly.

Economy and Lieberthal (2007) appeal to multinationals doing business in China to play a positive role in protecting China's environment by setting an example for practicing environmentally friendly production while impressing upon the Chinese government the demonstration of such conduct in their pursuit of profits. If it is in the interests of the multinationals to do so, one wonders why this would not be in the interests of domestic Chinese firms also. If such an undertaking is in their interests, why have the multinationals and Chinese domestic enterprises failed to pursue it? Why are the multinationals and the Chinese enterprises so ignorant of their own interests in this regard?

5. Two Proposals to Improve the Protection of China's Natural Environment

The first is based on the use of government power. The Chinese central government needs to find ways to enforce the laws for protecting the environment more strictly. A major hindrance to environmental law enforcement is the lack of cooperation on the part of local government officials who are interested in increasing the output of their own regions. The central government needs to establish and monitor a clear set of environmental standards and punish any governor of the violating province severely even to the extent of removing him from office. When Zhu Rongji was President of the People's Bank in the 1990s, he succeeded in restricting the quantity of money supply by a policy to remove from office any President of a provincial People's Bank which extended credit above the quota set by the Central Bank. The same strict rule for the enforcement of environmental policy may be needed. Given the risk of such a severe punishment a provincial governor would enforce environmental standards in the cities and counties in his province by adopting the same policy of punishing the offending mayors and county officials. Whether the central government would have the strong resolve to enforce environmental protection policies as suggested above is uncertain.

The second is based on the economic analysis of the problem. There are two major aspects of the problem of environment protection. The first is to decide what to regulate and how to regulate. In the case of pollution, for example, the government has to decide how much pollution should be allowed in each situation and whether the method should be a regulation to limit pollution or the issuance of emission permits which can be traded. The second is to enforce the laws for environmental protection effectively. In China, laws regulating pollution have often been violated.

The second proposal can solve both aspects of the problem using principles of economics. One basic proposition in economics is that resources will be efficiently allocated in the market when sellers controlling a resource try to get the most in selling it to buyers who also try to economize in its use. In such a situation there will be no waste. In the case of a natural resource like air and water in the environment, there are no private owners controlling it and users do not pay for using it, thus creating waste in the use of this resource. For a discussion of environmental economics the reader may refer to Uzawa (2005) and Tietenberg (2007). Imagine the possibility of giving property rights to the atmosphere to consumers who could sell them to producers in the form of emission permits at market price, the market forces of demand for and supply of emission permits would make the amount of air pollution optimal.

The proposal provides the Chinese citizens *de facto* property rights of the air and water in the area of their residence. Polluters of any amount will pay for pollution permits for that amount issued by the local office of the State Environmental Protection Administration on behalf of the local residents. The proceeds from the permits will be returned to the local Chinese citizens. The number of permits (total amount of pollutants discharged) will be determined by the citizens who can balance the cost and benefit of pollution in their area. Given the number of permits issued, demand will determine the price per permit. The government will first set an initial price for polluters to purchase the permits. If the price is lower than the equilibrium price, the permits will run out and some polluters need to purchase them from others at a higher price. If the initial price is too high, some permits will be unsold and the government will lower the price until all permits are sold. Local officers of the State Environmental Administration receive directions from local Chinese citizens through their representatives. Residents in rural areas can be represented by the popularly elected village heads. Urban residents can be represented by their popularly elected representatives of the locality. These representatives will be given responsibility to determine and will have incentive to enforce policies to protect the environment.

The proposed solution will also help solve the second aspects of the problem of environmental protection. The consumers will try to deter violators in order to protect their revenue from pollution. Both industrial polluters and local government officials who are more concerned with rapid growth in output in their locality than with protecting the environment have contributed to the violation of environmental protection laws in China. Chinese citizens, in cooperation with officials representing the central government to protect the environment, would help to enforce environmental protection laws and regulations in ways which they deem appropriate and which are allowed under the institutional arrangement to be established to put this proposal into practice. The violation of environmental protection laws has resulted in damage to the environment and protests of Chinese citizens. This proposal attempts to channel the energy of the protecting citizens to positive action through government channels.

I realize that in its present form the above proposal is only conceptual. Much remains to be done in utilizing the concepts advanced above to design precise institutional arrangements for Chinese citizens to participate in the protection of the natural environment for their interest and for the interest of the country. Two points should be noted here. First, I do not mean that this proposal is applicable to all cases of environmental protection in China. There are cases where direct regulation on the amount of emission allowed may be appropriate. Second, in terms of implementation the mechanism used to collect profit tax from enterprises can be used to collect fees for pollution also. Of course, monitoring the amount of pollution is required for the protection of the environment in any case.

This proposal echoes two major decisions for China's economic and political development. From the economic point of view it can be considered a part of the continued reform towards a market economy in order to harness the forces of market institutions to further China's economic development. From the political point of view it is a means for promoting the development of a democratic government. Democracy can mean power of the people to elect government officials. It also means power of the

people to make government decisions, to guide or even to direct government officials to serve the people's interests. Our proposal will help promote the second aspect of democracy.

6. Conclusions

Let me state the following six important points to conclude this paper.

1. China's environmental problems are serious; the government has been aware of this since the early 1990s and has tried hard to solve them.
2. Enforcement of environmental protection laws is difficult because local government officials often do not cooperate.
3. I propose, first, a stricter enforcement of environmental protection laws by removing negligent provincial governors from office, and, second, by giving the consumers the power and opportunity to regulate the amount of pollution by the use of emission permits in cooperation with government officials.
4. In spite of all efforts, the Chinese people, like any people experiencing rapid economic development, will pay the cost of environmental degradation for some time to come.
5. Looking further into the future, one can be optimistic because there is a positive income effect on the demand for a clean environment and there will be important technological innovations to discover alternative clean energy.
6. In the near future the environmental problem is not serious enough to hamper the rapid growth of China's economy which is driven by the fundamental forces of high-quality human capital, a working set of market institutions and a gap from the most advanced technology which enables China to grow fast to catch up as discussed in Chow (2007, chapter 10).

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