*Science & Global Security*, 1992, Volume 3, pp.43–47
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Printed in the United States of America

# COMMENTS ON "THE POTENTIAL FOR REDUCING $CO_2$ EMISSIONS IN CHINA WITH MODERN TECHNOLOGY"

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## INTRODUCTION

Before the 1970s, there was a clear relationship between energy and economic development: the development and exploitation of energy resources was considered the fuel for rapid development of the national economy. Since the 1980s, however, there has been an increasing environmental consciousness, and the energy situation of future generations began to be seriously considered in the present development of the economy. Coordinated development policies linking energy, environment, and economy were adopted. For a developing country like China, the means for environmental protection are hardly available without economic development. On the other hand, without environmental protection measures, sustainable development of the economy will be limited by environmental damage. Therefore, in the process of economic development, environmental protection measures should be adopted to reduce pollution caused by human activity.

China's energy production system is the world's third largest, producing about one billion tonnes of coal equivalent (TCE) or 30 exajoules annually, with coal accounting for about 75 percent. How to raise the efficiency of coal use in China or discover alternative measures to reduce environmental pollu-

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tion from fossil fuels are problems that have puzzled energy experts in and out of China. Robert Williams' scenario is a bold conception of an electricity development strategy for the next 50 years that does not increase $CO_2$ emissions. It describes a picture of future energy developments in China and suggests new approaches for China to contribute toward international solutions to the greenhouse problem.

## EFFICIENT ELECTRICITY END-USE

The author renews ideas from the well known book *Energy for a Sustainable World*, of which he is coauthor, about the extent to which living standards can be raised in a developing country through application of commercialized or soon-to-be commercialized technologies. He concludes that, with such technologies, a consumption of 1 kilowatt per capita would be sufficient for developing countries to achieve a standard of living comparable to that in Western Europe in the mid 1970s.

Williams' end-use oriented approach is commendable. It is a brilliant idea that developing countries need not repeat the approach that developed countries have experienced, but could instead choose a much more energy efficient approach to development. We believe this approach is technologically feasible. It is suggested that further analysis on the economic feasibility of this approach from the macro system point of view would be helpful, since this approach would require substantial change in the energy technologies that now exist in the developing countries.

## HYDROPOWER

The exploitable hydropower resource in China is about 380 gigawatts, the highest in the world. However, only about 9 percent of this was exploited in 1989. Thermal power investments have historically been perceived as less costly, contributing to the slow rate of hydropower development. The fair investment comparison is between a hydro plant and the total thermal plant and coal mine construction, as well as transportation costs. A very important final consideration is that the environmental impact and the cost of pollution prevention should be added to the total cost. (Desulfurization costs account for

about one third of the total thermal plant investment.) Most medium and large hydropower plants serve multiple purposes. In addition to electricity generation they provide flood prevention, irrigation water, aquatic recreation, as well as regulation of peak demand on the utility grid. The rate of hydropower exploitation will be accelerated in the coming five to ten years, during which time 3 to 4 gigawatts of new capacity will be installed annually. In addition to these increases, approval for and completion of the 17.68 gigawatt Three Gorges project is anticipated before the year 2000. There are few advocates of environmental protection who object to the development of hydropower resources. This is true even for the Three Gorges project. The major disagreement in this case is on when the project should proceed, sooner or later.

It is perhaps too pessimistic for Williams to estimate that only about one third of total exploitable hydropower resources can be developed by 2039. My personal opinion would be that half or more will be developed by then.

## NUCLEAR POWER

During the 14th World Energy Conference, it was stated that nuclear power is the only large-scale energy resource that can be developed without atmospheric pollution. As of 30 June 1990, some 533 nuclear plants were installed worldwide, with a total capacity of 414 gigawatts, accounting for about 17 percent of total electricity generation. Roughly 74 percent of the world's nuclear power is found in five developed countries—the US, Germany, the CIS, Japan, and France—indicating that nuclear power is more developed in richer countries.

In his article, Williams worries about possible future public objections to nuclear plants and their associated accident risks and waste disposal problems. He also expresses concern about the nuclear weapons proliferation that might accompany expanded nuclear power development. On these grounds, there are no objections to nuclear power development on the Chinese mainland. A shortage of capital for investment is the major reason for the slow rate of nuclear power development in China. It is estimated that, as the economy grows, the rate of nuclear power development will accelerate, gradually increasing its share of total electricity generation. Therefore, Williams' sug-

gestion that nuclear power will account for only 2.6 percent of total electricity generation in 2039 is probably an underestimate. We believe that the fast neutron reactor will be commercialized by this date, and that nuclear electricity will account for at least 10–15 percent of total generation, or about 300–450 terawatt-hours.

## EFFICIENT GAS TURBINE TECHNOLOGIES FIRED WITH NATURAL GAS

In full agreement with Williams, Chinese experts hope to have increasing opportunities to use clean, low-cost natural gas. However, Williams' estimate of the potential gas supplies is optimistic. We estimate that the exploitable natural gas resources are only about 40–50 percent of total reserves. Assuming this to be true, the total yield of natural gas would be 6–7 exajoules (150 billion $m^3$) per year, which is only about half Williams' estimate.

## USE OF COAL-DERIVED HYDROGEN IN FUEL CELLS

Coal accounts for 90 percent of primary energy reserves in China. Producing $H_2$ from coal, sequestering the $CO_2$, and using the $H_2$ in a fuel cell is one of the best ways to use coal efficiently and cleanly. Commercial technology is available for the production of $H_2$ from coal with separation of $CO_2$. Because of the attractive characteristics of fuel cells, this technology is undergoing rapid development. The Japanese government has carried out a long-term program to promote fuel cell development. Applications targeted for the early 1990s include office buildings, public facilities, hospitals, and stadiums. Industrial sector applications are targeted for the mid 1990s. The technology is projected to provide 13 percent of Japanese electricity by early in the next century. It is clear that the fuel cell will play an important role in power generation in the future, and thus will be available for use in China. However, there is no experience with sequestering of $CO_2$ in spent natural gas wells. Achieving commercial viability will require additional research and experimentation.

## BIOMASS-BASED POWER GENERATION

Using biomass to generate electricity can reduce $CO_2$ emissions. We agree with

Williams that biomass gasification technology can be commercialized in the 1990s. Over the past five years, gasification research in China has led to the development of three types of gasification stoves with gasification efficiencies of 75 percent and gas heating values of 6,200 kilojoules per $m^3$. The use of biomass gas to fuel diesel engines has also been successful. Central gas supply systems using agricultural residues were introduced first in China. Further technological progress will be made in the coming 50 years.

There is no problem using 26 million hectares to grow biomass for energy, as required by Williams' scenario. According to the national reforestation/afforestation program, the forest cover in China will reach 15–16 percent of the land by 2000. From 1989 to 2000, 57 million hectares will be planted, which is far more than the plantation area estimated in Williams' scenario.

It is uncertain whether an average of 10 dry tonnes of biomass per hectare could be produced. Firewood output averages less than 4 tonnes per hectare in the mountainous southern areas of China and less than 2 tonnes per hectare in northern mountain areas. The best yields recorded in these areas are 7.5 and 3.75 tonnes per hectare, respectively. To raise biomass productivity, plantation technology must be improved. Fortunately, there is time to undertake the required research and development effort.

## CONCLUSION

The scenario suggested by Williams would help promote the simultaneous development of energy, economy, and environment in China, and would also contribute toward controlling global emissions of greenhouse gases. Whether the scenario will be realized in the next 50 years depends on the economic viability of environmental control. At present, control of particulates and $SO_2$ is not stringent. There is not yet any regulation of $CO_2$ emissions in China, and there is currently no pressure to follow a greenhouse gas reduction strategy.

Because China is a developing country, it has limited economic means for improving the environment. For the benefit of the planet as a whole, the developed and developing countries should do their best to seek sustainable, environmentally sound development paths. Technological and economic cooperation will increase the possibility of realizing scenarios such as the one suggested by Williams.