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Chinese Energy Strategy and Policy: Fiscal Implications for the Ministry of Finance

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CHINESE ENERGY STRATEGY AND POLICY: FISCAL IMPLICATIONS FOR THE MINISTRY OF FINANCE

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Abstract

This paper examines issues in meeting China's rapidly rising demand for energy. The authors argue that, for the Chinese Government, the basic premise of China's energy strategy is sustainability: energy supplies should be secure, clean, cheap and, as far as possible, renewable. In turn, a sustainable energy strategy will require securing petroleum supplies, promoting clean coal technology, supplying rural energy needs, promoting energy-efficiency through appropriate prices and taxes, and developing a medium-term plan for energy supply that emphasizes conservation, environmental protection and security. Given China's technological capacities, resource endowments, and fiscal strength, the authors argue that clean coal, rural energy supply, oil substitutes, and renewable energy sources should be priorities for fiscal expenditure. New levies and taxes on energy use may also be desirable.

Key Words: China, energy policy, sustainability.

JEL Classification No: H54, O13

Part one: Background

Among the issues affecting Chinese economic security, three are paramount: security of the supplies of energy, water, and grain. Although these three issues are to be resolved mainly through the efficient exploitation of domestic resources and the development of China's domestic markets, the best solutions will not necessarily be based on self-sufficiency. Of these three major concerns for the Chinese Government (GOC), energy has become the most pressing issue in the GOC's current agenda. How China tackles its problem of establishing energy security has important implications for the rest of the world; whether other countries concern themselves about China's energy strategy because of its impacts on energy (especially oil and gas) prices, the global environment, important geo-political considerations or other reasons, they are paying close attention to what strategy China adopts. In its recent pronouncements, the GOC has made clear that the basic premise of China's energy strategy must be sustainability: energy supplies should be secure, clean, cheap and, as far as possible, renewable.

The speed of Chinese growth has been sustained over more than a quarter century, with the result that China is now the world's fourth largest economy (in nominal dollar terms), and Chinese demand increasingly contributes on the margin to serious pressures on global resources and the global environment. This became particularly evident as the Chinese economy experienced a renewed growth surge in 2003-04, leading to tightening supply conditions and sharply rising prices for many strategic commodities. The prices of petroleum, copper and iron ore were especially affected and, although short-term supply shortages contributed importantly to rising prices, clearly, rising Chinese demand also contributed powerfully. The impact of Chinese demand is not limited to these commodities; it also has affected the prices of such varied commodities as aluminum, cement, fertilizer, timber, and coal, as well as many others.

As a consequence of its rising economic might, China now has become the second largest energy producer and consumer after the United States. Comparing the two countries, in 2004, coal contributed 68 percent of China's energy consumption (and 76 percent of production); in the US 23 percent energy of energy consumption was from coal and 61 percent from petroleum and natural gas. In 2005, China consumed 2.14 billion tons of coal, 300 million tons of petroleum, 50.0 billion cubic meters of natural gas, 395.2 billion kwh of hydro-electricity, and 52.3 billion kwh of electricity generated from nuclear power. In total, the energy consumed from all of these sources in 2005 was equivalent to 2.22 billion tons of coal.[1]

China produces most of its energy resources internally, with the exception of natural gas and petroleum; China's dependency on oil imports is about 40 percent. Given the speed with which vehicle ownership and road transport are growing in China, the dependency on oil imports seems unlikely to fall over the coming decade. Along with the dramatic increases in private cars and other vehicles, the other two main drivers of energy consumption have been the changing industrial structure, especially the rapid development of the petrochemical industry, and the even more rapid development of the quality and quantity of housing and commercial property, with the associated demand for lighting, heating and cooling, and modern electrical appliances.

In 2003 and 2004, the energy elasticity of output growth in China was close to 1.5. Even after adjusting for the GDP revision in December 2005, the energy elasticity

[1] Different quality-level coals, petroleum and gas are converted to coal equivalence. See Appendix 1.

was still 1.3. Until the late 1990's, the energy elasticity was below 0.5; unless drastic changes can be introduced in China's recent patterns of energy consumption that performance is unlikely to be regained.

China's economic growth has not been an unadorned blessing. Along with rapid improvements in living standards an unwanted companion has been severe environmental pollution, affecting water, air, and land. Many of China's rivers and lakes, in particular, are polluted or severely polluted. And energy production is a primary contributor to airborne emissions, including greenhouse gases. China is now the second largest emitter of such gases after the United States, and will overtake the US by 2025, or much sooner according to some recent estimates.

The combination of sustained fast growth (a target of 7-8 percent a year for many years, even decades), with the associated rapid pace of industrialization and urbanization, and the likelihood of sustained heavy dependence on coal as the primary energy source have caused the environmental consequences of Chinese development to come under intense scrutiny both in China and abroad. The result domestically is a rising emphasis on the need both for efficiency in resource use, especially energy resources, and for a strategy for sustainable development in China. The search for a viable, sustainable energy strategy has emerged as a priority of the Chinese government. The purpose is to ensure that China's huge requirements for energy are met in ways that protect the environment and can be sustained indefinitely.

Part two: The core of Chinese energy strategy is sustainability.

The following section of the paper examines how to best implement a sustainable energy strategy in China based on domestic technological capacities, resources, and fiscal strength. As noted above, an acceptable strategy for China will ensure that energy supply meets four key criteria: it must be secure, clean, cheap and, as far as possible, renewable. This section considers actions in the short and medium term to achieve those targets: (i) securing oil imports and developing substitutes for oil; (ii) promoting the use of clean coal technology; (iii) finding low-cost solutions to the problem of supplying energy to rural areas; and (iv) promulgating policies to promote conservation and efficient use of energy resources.

A. Securing petroleum supplies

The principal problem of energy security for China involves the supply of petroleum.[2] During the initial years of the reform era – the early 1980s -- China was a major exporter of oil, mainly to Japan. With rapid growth, Chinese demand for oil soon out-stripped domestic production and in 2000-2005 Chinese oil imports climbed from 70.1 million tons (490 million barrels) to 127.1 million tons (890 million barrels). According to EIA (U.S.) and IEA projections, from 2000 to 2025 China and India together will account for a quarter of the increase in world oil consumption. Currently, China's dependency on oil imports is about 40 percent. With oil demand increasing rapidly, that dependency is likely to rise substantially pointing to the need to secure import supply and to develop a domestic capacity to produce substitutes for oil. To the

[2] Petroleum and oil are terms that will be used interchangeably to refer to all crude and refined petroleum products; those terms will also include natural gas unless otherwise indicated.

extent that domestic substitutes can be developed successfully, China can compensate for domestic shortages of oil, contribute to national energy security, and lessen the influence of volatile oil prices on the economy.

The China Association of Petroleum and Petro-Chemical Industry projects that Chinese oil consumption will lie between 350-400 million tons in 2010. Deducting domestic production projected at 180 million tons, the shortfall is 170-220 million tons, which in the absence of domestic substitutes would be supplied by imports. To maintain China's dependency on oil imports at the current 40 percent level would require imports to lie between 140-160 million tons, meaning that domestic substitutes would need to supply the equivalent of 30- 60 million tons of petroleum to avoid greater dependence on imports. Allowing for uncertainties in domestic production and imports, a prudent target for the Government to establish for domestic production of petroleum substitutes in 2010 would be 70 million tons.

But how feasible is this target? Essentially, the feasible options must utilize existing mature technologies, which probably means that, in addition to conversion of grain into ethanol, the principal bio-fuel, China would need to resort to technology that extracts oil from coal (CTO), as well as technology that converts non-grain biomass into an oil substitute (BTO). The Chinese Government already has launched a CTO program, which aims to produce 20 million tons (9 billion gallons) of oil from coal in 2010. In view of the calculations in the preceding paragraph, the program targets would need to be more ambitious, aiming to produce about 50 million tons (22.5 billion gallons) in 2010, or more.

Several factors suggest that a program of this scale would be possible. First, the technology to produce oil from coal is mature; and Chinese companies already have purchased such technologies from America and South Africa. Secondly, these technologies are reasonably cost-effective. Current projections suggest that the global oil price will exceed 60 dollars per barrel over coming decades. As CTO technologies generally extract a ton of oil from five tons of coal, these technologies are competitive at an oil price of around 28 to 35 dollars a barrel. Third, China's vast coal reserves promise not only the resources needed to substitute for petroleum in transport and power generation, but also to supply coal-based feedstock for chemical industries. Local Governments are interested in developing an integrated industrial chain involving CTO and associated industries. A mitigating fourth factor is the potential for severe pollution from an expanded use of coal. The Government will need to promote research and development of clean coal technologies that contain pollution and sequester carbon by-products. Supporting policies for CTO will have to encourage investment of non-public capital, including in R&D, and foster international cooperation in further developing clean coal technology.

This would leave another 20 million tons (9 billion gallons) to be supplied by ethanol and other BTO in 2010. Technologies to convert biomass into oil substitutes already exist and for per barrel *global crude* oil prices above *$45,* they can produce cost competitively. The attractions of BTO options include their renewable nature, their comparative cleanliness (compared to coal), and their potential to raise the incomes of poor farmers, who might be able to grow suitable source materials more profitably than grains or other food products. Clearly, BTO has considerable potential to ease China's dependence on oil imports over the longer term, making this a desirable source of new energy in which to invest.

Currently, the problems to resolve involve the small scale and comparatively high cost of BTO products. China has the advantage of abundant rural labor, so the planting costs of raw material would be comparatively low. This would help promote commercial scale production of BTO at current oil prices. But more has to be done to identify suitable source materials for conversion into bio-fuels, and that requires considerable investment in R&D into proving plant material suitable for large-scale cultivation and the technologies then required to convert massive supplies of raw materials into gasoline and diesel. Besides funding for R&D, the policies required to initiate large-scale production of bio-fuels might include subsidies to farmers to plant suitable plant varieties and to producers of BTO to invest capital in production facilities on a commercial scale.

B. Promoting clean coal technology

The promotion of clean energy in China is not just about clean coal technology, but includes also the development of sources of renewable energy, including nuclear power and hydroelectricity, as well as of natural gas. This paper, however, confines itself to the discussion of clean coal.

The dominance of coal as an energy source in China is shown in the table below, which shows patterns of Chinese energy production and consumption in 2004. The data are calculated from information provided in the China Statistical Yearbook and relevant energy data provided by the China Association of Petroleum and Petro-Chemical Industry. Comparing data for the structure of energy production from 1995 to 2000, to

2004, the share of coal has risen from 71% to 73%, to 75.6%, respectively. By contrast, the share of petroleum in production has fallen. On the consumption side, the opposite is observed, with a sharp rise in the share of petroleum leading to rapid growth of oil imports.

Table 1: Chinese Energy Production and Consumption: by source, 2004.

Source of energy	production share (%)	consumption share (%)
Coal	75.6	67.7
Petroleum	13.5	22.7
Natural gas	3.0	2.6
Hydroelectricity	7.9	7.0
Nuclear power	1.0	1.0

The dominance of coal in the energy mix is such that Chinese energy supply will be based mainly on coal for several decades. Even if there was a fundamental change in structure in coming decades, the Chinese Government would still need to promote new clean coal technologies, the purpose of which would be to reduce the discharge of pollutants and cut down emissions of greenhouse gases. Along with the elimination of particulate emissions, clean coal technology also should minimize the associated emissions of sulfur ($SO2$) and carbon ($CO2$, CO).

Many techniques exist that mitigate the ill effects of burning coal, including washing coal, removing dust (particulates), desulphurization, gasification, and liquefaction. In addition, there is considerable potential in methods of electricity generation from coal that dispense with the need for burning (for example, integrated gasification combined cycle techniques – IGCC). In all these areas, however, improvements in technology would help to reduce coal's detrimental effects further, meaning that China -- together with international partners, where appropriate -- should assign high priority to funding research on new technologies for clean electricity generation from coal.

Of equal or even greater importance in implementing clean coal technology is the need rapidly to introduce proven clean processes. Many existing Chinese power plants lack the capacity to eliminate dust and sulfur emissions to the extent permitted by modern equipment. More funds are needed to retrofit existing facilities to bring them up to required standards. And more new investments should adopt the least polluting technology rather than simply opting for the technology of lowest cost. China should assure other major coal-burning nations of her willingness to acquire low-polluting coal technologies as they develop them, and possibly could support investment in research in other countries under suitable arrangements. China can ill-afford to rely on self-development of new technologies, but should take advantage of every opportunity to purchase existing technologies and to cooperate with America and India in developing clean coal technology.

*C. **Supplying rural energy needs***

In China, 750 million people live in rural areas, about 100 million of whom live in remote areas. Supplying their energy, especially electricity, needs cost effectively is an important priority of the government, and a key component of Chinese energy strategy. Several options are available to contribute to resolving problems of rural energy supply.

(a) Promote small-scale hydroelectricity development

China possesses rich hydro resources in rural areas, and the technology of small-scale hydroelectricity generation is mature. Moreover, the cost of small-scale hydroelectricity is a third to a half lower than power from large hydroelectric projects and it is also lower than thermally-generated electricity in south-west and central-south China, particularly in Yunnan, Guizhou, Sichuan and Hunan. Because the initial capital investment scale is small, the cost burden on local farmers is reduced. Second, considerable savings can be realized by eliminating the need for long-distance transmission of electricity. Third, small multi-purpose dams also provide the benefits of irrigation and drinking water. On balance, therefore, the promotion of small-scale hydroelectricity development in rural areas is both desirable and feasible. The Chinese Government already has initiated an accelerated program of small-scale hydroelectricity development in rural areas as part of the efforts to construct a new socialist countryside. Supporting policies include Governmental investment subsidies for project construction, encouragement for co-operative construction and operation, and preferential tax treatment, including exemption from taxation.

(b) Expand methane-generation pits in rural area

The generation of methane from human and animal wastes and other waste products is inexpensive and is already a substantial source of energy. It has the added benefit of contributing to improvement of the environment in rural areas. Methane generation is a mature technology in China that was developed primarily during the 1950s to 1970s. Beginning in the 1980s, progress in developing and extending the technology slowed sharply.

Since 2003, the Chinese Government has re-launched the initiative, as part of the strategy to construct a new socialist countryside. The central and local Governments provide investment subsidies for methane pit construction in central and western regions, and local Governments also provide technical supporting services. In analyzing the cost-effectiveness of this form of energy for rural residents, one needs to allow for the Government subsidy of 800-1000 RMB for each family compared with a general initial capital investment of 1000-1500 RMB. The subsidy makes the construction cost affordable for most rural families. Operating costs are minimal, essentially just the labor to collect all kinds of wastes, with no needed cash outlays. Given that most farming families are not fully employed in land cultivation, the effective operating costs for farmers are zero.

The Chinese Government would do well to accelerate the development of energy from methane-generation pits in rural areas. The energy generated from this method is both economical and comparatively environmentally benign. Using wastes in this manner also contributes to a cleaner environment and more sanitary conditions in rural areas. The key to wider adoption, however, is the provision of more budgetary funds from the central and local Governments to subsidize the construction of methane-generation pits, in turn requiring careful consideration of the affordability of the process if it is to be implemented comprehensively throughout rural China.

(c) Expand the conversion of biomass to oil

Just as large-scale production of crops for the production of ethanol and other oil substitutes promises to reduce China's reliance on imported petroleum, it also has the potential to help raise farmers' incomes. Although it is not a solution solely for rural areas, this option has the potential to alleviate rural energy problems as it provides a cost-effective substitute for petroleum.

(d) Develop solar and wind energy

For remote areas of China, where electricity transmission is both difficult and costly, the development of solar energy and wind energy has considerable potential to meet energy needs. Because both of these energy sources are still expensive ways to generate bulk power, in most cases Governments will need to subsidize the capital costs for people to be able to afford them, especially because most people in remote areas far from the grid are very poor. Despite high capital costs, these renewable options might still be the best ways to supply electricity to many isolated communities.

(e) Encourage migration

A potentially cost-effective alternative to supplying electricity to residents of remote areas is to encourage relocation to areas where the cost of meeting energy needs is much lower. This option is particularly attractive in those situations where the capacity to support communities at reasonable living standards through agricultural activities is low, currently and prospectively. Encouraging managed migration of communities from resource deficient areas has the additional benefits of returning marginal farm land to pasturage or forest cover with evident environmental and ecological benefits.

D. Promoting energy-efficiency in China through appropriate prices and taxes

China's energy strategy emphasizes both expanding energy supply and promoting energy-efficiency. In the current situation, promoting energy-efficiency seems the more urgent of the two tasks. China has huge potential for enhancing the efficiency with which energy is used. Lowering China's current energy elasticity from 1.5 to 1.0 would reduce 4.5% of total energy consumption. If energy elasticity fell further -- to 0.8 or 0.5 -- which seems feasible with the implementation of appropriate policies, energy consumption would be reduced 6.3% or 9%. Raising the current efficiency of China's thermal power plants from an average 40% to an average 60% would reduce coal consumption in China by 300 million tons a year, or roughly 10% of total energy consumption.

America provides a good example of what is possible. In the U.S. during 1970-2000, GDP grew by 164% and population grew by 37%, but energy consumption grew by just 42%. The marginal energy elasticity was only 0.25. Meanwhile, the six main emissions (SO_2, NO_2, CO, Ozone, Lead (Pb) and air-particles) were lowered by 28% to 98%. Of course, America's energy saving was related, in part, to the changes in the industrial structure of the U.S.

To promote energy conservation and efficiency in China depends first on pricing energy appropriately. Enterprises and consumers will respond to market prices that reflect the full cost of energy supply, including appropriate taxes to mitigate environmental damage and to compensate for depletion of non-renewable resources. In most, if not all, cases, market prices for different sources of energy should rise to promote energy-efficiency. The potential for energy saving is greatest in industry, transportation and construction.

(a) Promoting energy-efficiency in industry

A combination of measures is required to encourage industry to use energy more efficiently; these include conservation, technological innovation, and revised standards. First, conservation measures could help to control energy consumption in heavy-chemical industries, which are the main energy consuming industries. Second, measures to accelerate technological innovation in enterprises that produce iron and steel, cement and nonferrous metals could reduce energy consumption substantially and at the same time contribute environmental benefits. In addition, technological innovation in new and existing power generation facilities could raise the efficiency of thermal power plants dramatically. Finally, the government should give priority to a revision of industrial energy standards accompanied by improved environmental safeguards.

Once an accepted set of energy standards are in place, the government can then promote the use of energy-efficient-products. Government procurement could specify the standards for energy consumption that specific products should meet to be eligible for purchase under government contracts. To encourage public bodies to purchase energy saving products the government could also organize demonstrations of approved products to convince officials of their suitability for use. Government research organizations should be encouraged to develop more energy efficient products that would raise standards further. Finally, consumers could be offered incentives to purchase energy-efficiency products. Or, if this proves undesirable for fiscal or other reasons, a tax could be levied on less energy-efficiency products to lower the relative prices of energy-efficiency products.

(b) Promoting energy-efficiency in transportation

As the earlier discussion makes clear, China depends increasingly on imported petroleum for her energy needs. Looking ahead, rising oil consumption will result mainly from increased consumption by vehicles. In 2005, vehicles accounted for 35% of China's oil consumption, but that share is projected to rise to 57% in 2020. The promotion of energy-efficiency in transportation will have major environmental benefits and will help to lower China's dependency on oil imports.

The key measure to promote energy-efficiency in transportation is to raise the sale price of gasoline and diesel fuel by levying a fuel tax. To complement appropriate pricing policy, the government also should move aggressively (i) to accelerate the elimination of out-of-date vehicles, (ii) to encourage the purchase of medium and small engine cars (by taxing vehicles with high-displacement engines), (iii) to encourage commuters to form driving-pools, (iv) to emphasize public transportation wherever possible as an alternative to private vehicles, and (v) to support research and development into fuel efficient, including hybrid, vehicles and/or to foster technological co-operation on fuel-efficient vehicles with America and Japan.[3]

(c) Promoting energy-efficiency in construction

There is huge potential for energy savings in construction in China. Several measures are required to realize these savings. First, Governments at all levels need to establish and enforce standards for energy-efficiency in buildings. Better insulation and more attention to appropriate materials would sharply reduce energy losses in heating and cooling. Second, priority should be given to accelerating the retrofitting of existing buildings to meet required energy-efficiency standards. Third, efforts to develop and promote the adoption of new, energy-saving building materials should be encouraged. Fourth, all buildings should be metered to enable monitoring of energy consumption. Finally, and most importantly, to ensure that appropriate incentives are in place to introduce these improvements, energy prices should rise to reflect their social costs.

Governments should take the lead in improving the energy-efficiency of buildings by demonstrating what can be done to reduce energy use in Governmental buildings. Targets should be established for energy use in all Government buildings, and metering and retro-fitting should ensure that those targets are realized. Beyond that, all Government agencies should be required to purchase energy-efficiency products and to establish regulations for Government procurement of energy-efficiency products.

[3] The potential savings over the average of 23 miles per gallon of gasoline is illustrated by the fuel savings of the Toyota hybrid. The hybrid Toyota Camry gets 1.67 times the mileage of its standard, 4-cylinder counterpart in city driving (1.12 times for highway mileage), while the Toyota Prius achieves 2.5 times the gas mileage of the standard Camry in city driving (1.5, highway).

Many of the measures the government can adopt to promote energy-efficiency are neither expensive nor dependent on huge investments. The obvious methods are appropriate tax and pricing policies, which have great potential to establish strong incentives to conserve energy in industry, transportation, and construction. The Chinese Government ought to consider options for exploiting the market mechanism to promote energy-efficient behavior of enterprises and individuals. In the case of Governments and other public bodies, pricing policy can be reinforced by regulation that emphasizes energy saving in all activities in the public sector.

The immediate priority is to price energy resources appropriately. In China, the price of most energy resources is lower than the social cost of their use, and that is true especially for petroleum and coal. The prices of electricity, gasoline, and coal burned in thermal power plants are still controlled, and sometimes capped, by the government to the detriment of energy-efficiency. Ideally, carbon fuel prices should also include a tax both to promote conservation and to recognize that their use harms the environment. This would encourage the use of more environmentally benign sources of energy, including renewables. Greater impetus to use less-polluting energy sources could be spurred by extending subsidies or tax relief to producers and consumers who adopt energy-saving measures.

E. Towards a medium-term strategy for energy-efficiency in China

There are other measures that could contribute to a viable medium-term energy strategy for China that emphasizes conservation, environmental protection and security of supply. They include:

(a) Adoption and enforcement of energy standards. China lacks energy standards in many areas. Moreover, numerous standards that do exist are either out-of-date or neglect the advanced standards now feasible in a variety of applications.

(b) Adoption of daylight savings time in China. China introduced daylight saving in 1986, but soon abandoned it. We propose that the Chinese Government re-introduces daylight saving time, together with a division of the country into different time zones designed to align activity as far as possible with daylight hours. According to projections by some experts, the adoption of daylight savings alone has the potential to reduce total energy consumption by one percent a year. Put differently, this would achieve a quarter of the target reduction for energy consumption per unit of GDP during 2006-2010 (the eleventh five-year plan period).

(c) Promotion of recycling. Recycling of waste materials has the capacity greatly to reduce the consumption of primary resources and, in many cases, also to save energy. China already has several successful recycling operations underway.

(d) Promotion of technological co-operation on energy-efficiency. China's capacity for research and development of alternative energy sources is limited, but China has much to gain (and to contribute globally) if advances can be made in clean coal technology, energy-saving devices, renewable energy sources, and so forth. Accordingly, China should seek opportunities to cooperate with OECD member countries in projects designed to find energy solutions. For example, China could cooperate with America and Japan to develop hybrid vehicles or vehicles powered by fuel cells.

In the short- and medium-term, Chinese energy strategy will continue to center on securing access to adequate supplies of carbon-based fossil energy, primarily petroleum and coal. Mitigating the environmental consequences of supplying China’s energy needs will depend mainly on raising the efficiency with which carbon-based fuels are used. Based on known reserves, most of China’s petroleum deposits will be exhausted within 25-30 years, after which China will be wholly dependent on imports. Reserves of coal are sufficient for centuries, but carbon emissions from coal threaten to be a growing and insoluble problem. If China is to develop an environmentally responsible, long-term energy strategy, ways must be found to substitute for fossil energy in China.

What are the likely substitutes for fossil energy in transportation and power generation? Currently, the best prospects seem to lie in hydrogen fuel applications and power generation from renewable processes. In both its domestic and international research pursuits, these are the areas that are likely to be most fruitful for China. There are many known options for sourcing hydrogen for fuel or power, including: solar power devices that could produce both electricity and hydrogen; production of hydrogen at existing wind energy facilities; extraction of hydrogen from seawater or fossil fuels; and the development of hydrogen fuel cells.

If these are the main prospective areas, they are also the priority areas for research and institution building, implying that China should finance research and development and seek opportunities for international cooperation in (i) basic research on hydrogen energy, including the development of hydrogen fuel cells for vehicles and extraction of hydrogen gas from fossil energy and seawater; (ii) solar power devices and wind energy facilities for electricity generation and for sourcing hydrogen for fuel; and (iii) the development of efficient hybrid and hydrogen-powered vehicles.

Another potentially fruitful area for Chinese research is in the conversion of renewable and waste resources into bio-fuels. As discussed above, potentially valuable areas for expansion as substantial energy sources include: (i) ethanol production; (ii) methane-generating pits in rural areas; (iii) conversion of biomass into petroleum substitutes; and extraction of fuel from other agricultural wastes (e.g. poultry fat and poultry waste).

Part three: Establishing fiscal priorities

Certainly in the next few years and probably for considerably longer, the limitations imposed by the availability of budgetary funds will constrain China's capacity to support research in all of these areas. Increasingly, domestic and foreign private ventures can be expected to invest in researching energy options for China in the expectation of profiting from successful innovation. On behalf of the Government, the Ministry of Finance (MOF) will need to assign limited research funding to the areas that offer the greatest potential for yielding high returns. The MOF also can suggest ways to raise additional funds for energy research.

(a) Priorities for expenditure

The priorities for fiscal support in energy development should be:

- *Clean coal.*

As coal will continue to be China's main source of energy, developing clean coal technology will provide important benefits and improve the trade-off between energy needs and protection of the environment. The MOF should help to fund research and development of clean coal technology by domestic enterprises. It should also help promote international cooperation with the U.S. and India in researching clean coal. The U.S. has developed the mature technology of integrated gasification combined cycle (IGCC), which converts coal into gas that is burned to generate electricity. China could investigate ways in which to cooperate with American enterprises in further research and/or acquire the IGCC technology under license arrangements. India also mainly depends on coal to meet energy needs, and therefore shares similar issues with China. Both countries have a common interest to cooperate.

- *Rural energy supply.*

Of China's 1.3 billion people, 750 million live in rural areas. A pressing concern for the Government is how to develop and supply low-cost energy to rural areas. Fiscal support should continue to promote the development of small-scale hydroelectricity in rural areas, with central and local budgetary funds subsidizing the associated capital investments. For central budgetary funds, the focus would remain on rural areas in the central and western regions. Furthermore, budget support should assist in the development of methane-generation pits in rural areas. The MOF will need to cooperate with the National Development and Reform Commission and Ministry of Agriculture to strengthen initiatives in disseminating this technology more widely in rural areas. Funds should aim to increase coverage of the technology and to raise the level of central investment subsidy. Finally, in many rural locations there are no appealing, low-cost options for supplying energy. The preferable strategy for some remote and/or poor regions might be to encourage residents to relocate, in which case central budgetary funds could be allocated to facilitate relocation.

- *Substitutes for oil.*

Fiscal support for supplying substitutes for oil should give priority to producing more ethanol, which currently is only an additive to gasoline. Potential exists to develop ethanol as a substitute for gasoline, and encouragement should be given to widespread use of E85 in the near future. The second priority is to support efforts to convert biomass into oil/fuel (BTO). The objective should be to achieve commercial scale production; beforehand, fiscal support should be provided for research and development, along with temporary VAT rebates for early producers of BTO. The decision on whether or not to subsidize growers of biomass would need to be based on the availability of Government budgetary funds.

There should be no need for Government support of efforts to convert coal to oil/fuel (CTO). At current oil prices and with available technologies, CTO should be commercially attractive. Development can be left to the enterprise sector.

- *Sources of renewable energy*.

The Government assigns high priority to expanding renewable energy supplies, including most notably solar power (for heating and solar fuel cells), and wind power.

Limited resources could be allocated to research on applications in these areas: at the same time, the Government should seek opportunities for international cooperation to develop efficient solar fuel cells and improved equipment for wind power. Hydrogen energy is also a high potential area for China, but one in which international cooperation with the U.S., Japan and Europe in research and development appeals as the best approach.

(b) Supplementing fiscal resources for energy R&D

Limited fiscal resources for energy investment could be augmented by new levies and taxes on energy use, which would have the added benefit of encouraging conservation. Revenues raised thereby could constitute a special budgetary fund for renewable energy research and for subsidies to investments in new energy supply. The immediate source of revenues could be from a tax on consumption of fossil fuels (petroleum and coal). Alternatively, a levy could be placed on electricity use. For example, in 2005, generated electricity volume totaled 2,475 gigawatt hours (GWH) (which is the actual volume of electrical output generated, not potential based on installed capacity), of which thermal power generation contributed 2,018 GWH. If a tax of 0.01 RMB yuan per kilowatt hour was levied on thermally generated electricity, 20 billion RMB yuan could be raised to finance the development of renewable energy. In China, the average cost of thermal power is roughly 0.22 RMB yuan per kilowatt hour, so the tax would raise generation costs less than five percent.[4] The proposed fossil fuel tax or fossil fuel fund, could

[4] For comparison purposes, the cost per kilowatt hour of wind-generated electricity is about 0.40 RMB yuan, meaning coal-fired generation would remain cheaper than wind-based alternatives even after the levy was imposed.

supplement the additional provision of central and local Governments' budgetary funds for energy R&D and investment in new energy capacity.

Introduction of a fossil fuel tax should be part of a comprehensive review of China's energy-pricing policies. China has a high elasticity of demand for energy relative to GDP and correspondingly low energy efficiency. Although some obsolete technology and traditional notions about consumption contribute to low efficiency, an important reason for inefficiency is the low energy price. Some of China's domestic energy prices are not only lower than international market prices, but also lower than the domestic cost of the energy resources on which prices should be based. The thrust of energy-efficiency reform must be to establish appropriate pricing policy: the prices of energy resources have to completely cover costs -- of the resource assets employed, of handling and distribution, including safety provisions, and to the environment.

A priority for MOF in contributing to better energy pricing policies will be to direct research on how best to introduce taxes and fees on energy resources to promote energy efficiency. An important, albeit controversial, area for research is the feasibility of a carbon tax and how to levy it, both to promote efficiency and to limit the emission of greenhouse gases. In all cases, the revenues raised can help to increase the special budgetary funds available to support R&D on substitutes for fossil fuels, as well as investments to secure longer-term energy supply.

The most urgent area for attention is the scope for taxing the use of petroleum fuels. In China, the crude oil price is linked to the international market price. But the distribution and pricing of refined products are controlled, and often conducted, by the Government. In recent years, the Chinese Government has introduced reforms in the distribution and pricing of refined petroleum products, raising their prices twice in the first half of 2006. The objective of higher prices is the same as that of prospective fuel or gasoline taxes: the promotion of energy-efficiency and the curtailment of emissions. Finally, the MOF will need to recognize the detrimental effects that fuel taxes could have on the providers of important public services (e.g. in-city transportation) or on the incomes of poorer groups (e.g. farmers). Consideration would need to be given to providing fiscal subsidies to offset the costs of taxes and levies in special circumstances like these. (Of course, compensation would be provided best by a direct transfer payment rather than an exemption from the tax, which would remove the incentive to conserve fuel.)

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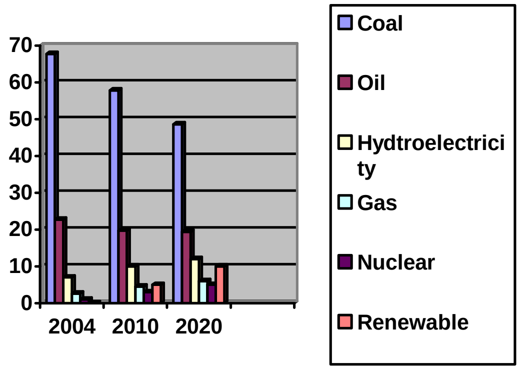
Appendix 1:

The Projection of Chinese Energy Consumption/Production in 2010, 2020

	2004		2010		2020	
Item of Energy	Amount of Production/ Consumption	% of Total Energy	Amount of Production/ Consumption	% of Total Energy	Amount of Production/ Consumption	% of Total Energy
Total Converted Energy (billion tons of coal equivalence)	1.97	100	2.64	100	3.30	100
Coal (billion tons)						
--Production	1.956		2.35		2.65	
--Consumption As Energy	1.87	67.7	2.11	57.8	2.39	48.6
Petroleum(≤1+2+3) (billion tons)	0.29	22.7	0.35	19.7	0.4	19.4
--Domestic Production(1)	0.17		0.18		0.18	
--Import(2)	0.12		0.14		0.16	
--Substitutes(3)	---		0.07		0.08	
Natural Gas (billion cubic)	41.5	2.6	90.2	4.5	161.0	6.0
Hydroelectricity (billion KW)	328.0	7.0	629.0	10.0	942.0	12.0
Nuclear Power (billion KW)	50.1	1.0	202.0	3.0	413.0	5.0
Renewable Energy	---	---		5.0		10.0

Appendix 2:


70
60
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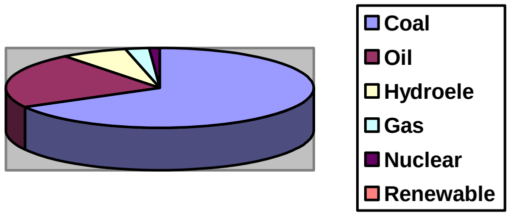
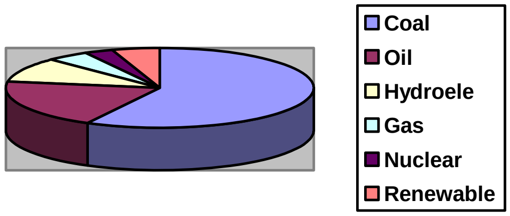
2004
2010
2020
Coal
Oil
Hydtroelectricity
Gas
Nuclear
Renewable


Coal
Oil
Hydroele
Gas
Nuclear
Renewable


Coal
Oil
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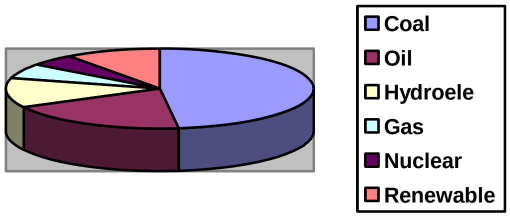
Nuclear
Renewable


Coal
Oil
Hydroele
Gas
Nuclear
Renewable