Energy Conservation as Security

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Redefining Energy Security

"Energy security" is usually defined as the guarantee of a stable and reliable supply of energy at reasonable prices. However, this definition is often misleading because it equates oil supply as the primary focus of a country's energy security considerations. As a developing country with a limited natural resource endowment China does not rely on oil alone. Instead China is one of the few economies in the world that still uses coal as one of its main sources of energy. Therefore, energy security in China is more comprehensive because it must consider the supply of coal, gas, electricity and nuclear energy along with oil imports.

In addition to resource supplies, a country's energy security also depends on a number of domestic and international factors. Energy prices and the circumstances of the international energy market are important external elements. The degree of an economy's dependence on energy, a country's contingency capacity including strategic reserves, standby production capacity alternatives for energy substitution, energy efficiency and technical capacity are all key domestic considerations for a nation's energy security. In these broad terms, China's energy security is unquestionably more fragile than many developed countries. Consider the basic fact that in China, the maintenance

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of social and economic development requires higher energy intensity than in developed nations. End-user expenditure on energy in China accounts for 15.7 percent of GDP, while the figure is only 7 percent in the United States.[1] Reducing both the direct and indirect (externalities) expenses of China's energy mix can only come from serious conservation measures.

Table 1 China's Energy and Key Economic Indices[2]

	1990	2000	2005
Year-end population (millions)	1143.33	1267.43	1307.56
GDP (billions of U.S. dollars)	232	1118	2279
Per capita GDP (U.S. dollar)	204	886	1743
Primary energy consumption (million tons coal equivalent)	987.0	1385.5	2224.7
Per capita energy consumption (kilogram coal equivalent)	863	1093	1701
Power output (trillion watts)	621.2	1355.6	2474.7
Steel output (million tons)	66.35	128.50	352.39
Net oil import volume (million tons)	-23.46	74.00	143.61
SO 2 emissions (million tons)	14.95	19.95	25.49

Energy conservation is the most realistic and economical approach for China to achieve a viable energy security. Research shows that the net costs of wind energy, hydropower and nuclear power as programs for reducing fossil fuel use and corresponding CO_2 emissions are 6.1, 6.2 and 7.0 times more than energy conservation.[3] There is huge potential to make large efficiency gains using energy conservation and therefore it must be the priority of an energy security strategy. In the 11th Five-Year Plan (2006-2010), the Chinese government has committed to bring the country's overall energy intensity down by 20 percent.[4] This would effectively make it the most ambitious energy conservation program in the world. As energy conservation is vital to China's energy security, it is important to understand how the government is faring in achieving its goals and whether these goals are indeed realistic.

The Inevitability of Demand

Much ink has been spilt over analyzing the nature of China's economy and how it will be fueled in the future. There is little doubt that China's demand for energy will rapidly increase in the foreseeable future. [5] Yet, understanding the structure of its energy consumption patterns is crucial in order to create effective policy prescriptions to improve energy efficiency and to promote conservation. Structural changes in industrial production have been the primary reason for China's rapid increase in energy demand. Beginning in the early 1990s, China entered a new round of heavy industrialization. Heavy industry comprised 66.5 percent of China's total industrial production value in 2004; up from a level of 50.6 percent in 1990. [6] Notably, the energy consumption per unit of production value (energy intensity) in heavy industry was four times higher than the intensity for light industries.

The structural change in China's energy demand lies primarily in the rapid acceleration of urbanization and people's consumption patterns.

The reason for this fundamental shift lies primarily in the rapid acceleration of urbanization throughout the country and the attendant changes in people's consumption patterns. The rate of population migration from the rural areas to the cities is unprecedented in human history. From 1978 to 2004, China's urbanization rate rose from 17.9 percent to 41.8 percent, increasing the total urban population from 170 million to 540 million. [7] Equally staggering is that the current per capita energy consumption in China's cities is three and a half times more than in the countryside (a disparity that is far higher than in developed countries).[8] Compared to their rural counterparts, urban dwellers demand more living space, more automobiles and more home appliances, all of which entail highly energy-intensive industries.

In addition, China is expending an enormous amount of energy in its role as "factory of the world." China produces one-third of the world's computers and refrigerators, one-half of its textiles, digital cameras and DVDs, and 60 percent of the air conditioners, microwave ovens and copy machines bought around the globe. The huge demand in the domestic and international market for Chinese goods drives the rapid growth in the output of products requiring high energy-consuming industries. The benefits of becoming the world's primary manufacturer are offset by the costs of the staggering consumption of both energy and other commodity resources. In 2003, China burned up 32 percent of the global aggregate coal output, 26 percent of global steel output, 25 percent of its copper and aluminum and 40 percent of the world's cement.[9]

Looking to the future, as urbanization and the structural upgrading of consumption look set to continue for a very long time, China's output of high energy-intensive products will only continue to grow. As a result, a vast rise in China's demand for energy will simply be unavoidable. Several forecasts predict that by 2020 China's primary energy demand will be between 3,300 and 3,700Mtce or between 1.5 and 1.7 times its demand in 2005.[10]

Energy Efficiency Floundering[11]

Since the reform and opening-up, China has actually made great strides in energy conservation in an effort to address escalating consumption. Between 1980 and 2000, China's annual GDP growth averaged 9.7 percent, while primary energy consumption grew by only 4.6 percent annually, giving an energy consumption elasticity coefficient of 0.47. Given the strains of "middle industrialization" (period of rising heavy industry in economy), this is actually a remarkable achievement. Yet, since 2002, China's energy conservation rate has deteriorated. That is, energy demand has been increasing faster than China's GDP growth, reversing the trend of its declining energy intensity and leading to a jump in its energy consumption elasticity to 1.6 between the years 2003 and 2004. While this may be a temporary abnormality, it could nevertheless be a signal that the role of structural energy conservation is weakening.[12]

In the first place, there is a phenomenal waste in China's energy production. The overall efficiency of the energy sector stands at a mere 11 percent. In other words, only slightly more than a tenth of the recoverable energy reserves are converted into end-usable energy, while almost 90 percent of it is lost or wasted in exploitation, processing, conversion, transportation, storage and end utilization process. Such low efficiency of the energy sector translates into higher energy end-product expenditures. For instance, the average cost of China's domestic oil refinery production was 30 percent higher than that of their foreign competitors.[13]

Secondly, energy efficiency in China remains very low despite the overall progress in conservation over the past decades. Currently, domestic energy intensity is about 50 percent higher than that of other developing countries with similar conditions. China also continues to lag far behind advanced country levels of energy efficiency, especially within energy-intensive product industries. In 2004, coal consumption per unit in China's fossil fuel power plants was 20.5 percent higher than developed country levels, for steel-making it was 15.6 percent higher and for cement-making it was 23.3 percent higher.[14]

In 2004, the average energy consumption index of 16 products within seven of China's industrial sectors (power, steel, non-ferrous metals, construction materials, petrochemical, chemical and light industries) was 40 percent higher than that of the world's advanced economies. This situation is due in large part to the low energy efficiency of general-purpose equipment used in these industries. For instance, the average operational efficiency of small and medium-sized electric motors in China is 87 percent, while the figure is 92 percent in the United States; for coal-fired industrial boilers it is between 60 and 65 percent in China, while the figure is over 75 percent abroad.[15]

The energy efficiency of buildings in China is also egregiously low. Surveys of residential structures with heating in Beijing, Tianjin and northeast China reveal the average amount of energy consumed per heating unit is 24.2 kgce/m^2, or 3.9 times that of Germany, which has similar climate conditions.[16]

As China's rising middle class seeks to purchase more cars, fuel efficiency standards will significantly impact the country's energy consumption patterns. But here too, China lags behind in fuel economy. Currently, the average oil consumption for all automobiles is more than 20 percent higher than developed nations, while for light trucks China's is over 25 percent higher. [17]

Structural Potential

Energy conservation is simply the effort of lowering energy intensity for any socially or economically productive activity. However, the range of tools to improve conservation goals can include economic, technological, legal and administrative methods, as well as publicity and education, while their availability and effectiveness depend on the particular cultural, socio-economic and political conditions of a nation.

Structural shifts in the economy are extremely important elements in energy conservation because they have both the potential to cause significant shifts in energy intensity and because there is an inherent incentive to implement structural improvements: energy costs and dependence on energy can be alleviated. Structural factors entail the make up and scale of the industrial sector, enterprises, as well as product composition, energy mix, and even the structure of trade (import and export of energy-intensive products).

Industrial structure adjustments in the economy mainly involve moving from heavy industry to higher technology and service sectors that require less energy intensive activity and have higher added-value. The energy intensity of China's business sector is merely one-fifth of the average of heavy and light industries. Improving the structure of economic production requires developing new energy-conserving, environment-friendly construction materials, high concentration fertilizers and the like. Adjusting energy structure means shifting domestic energy consumption from coal to higher efficiency energy such as electricity, gas and steam. All developing nations face these structural challenges and their implementation that, although vary in difficulty, are relatively straightforward.

Enterprise structure, however, is more unique to China. The evolution of China's enterprises has been instrumental in leading the country during the early stages of China's rapid economic growth of the past 20 years. In the initial stages of reform, many small and medium sized enterprises sprang up in villages and townships around the country as they were more versatile and adaptive to taking advantage of the rapidly changing policy and market environment of the moment. Many of China's energy-intensive and highly polluting enterprises belong to this group of smaller scale enterprises. Within the energy intensive industrial sector, small industries use 30 to 60 percent more energy per output than larger-scale enterprises.[18] Unfortunately, the former produce the majority of output of these energy-intensive items. Surveys show that smaller scale industrial enterprises account for some 50 percent of the total energy consumption of China's entire industrial sector.[19] These enterprises continue to use backward production techniques and high energy-consuming raw materials, all of which are exacerbated by their lower level of technical equipment and management methods. For example, in 2004, the average annual pig iron (raw iron) output of blast furnaces in China was 750,000 tons, while in Japan the figure was 2.83 million tons. There are as many as 5,027 cement factories in China, with

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a mean annual output of a mere 190,000 tons. By comparison, the figure is 1.14 million tons in Japan. The challenges in altering the production and energy consumption patterns of these enterprises are formidable. Many of them have deep political and economic relationships with local governments

Table 2 International Comparison of the Enterprise or Facility in Energy Intensive Industry (2004)[20]

Category	China	Foreign
Coal Mines	28,000 with average annual output of 70,000 tons	9 in Germany, average annual output of 5.56 million tons
Refineries	56 with annual processing capacity of 4.19 million tons	6 in South Korea, annual processing capacity of 21.47 million tons
Blast Furnaces	263 with average annual steel production of 750,000 tons	29 in Japan, annual steel production of 2.83 million tons
Cement Factories	5,027 with an average annual output of 190,000 tons	65 in Japan, average annual output of 1.14 million tons

and interests, making their behavior difficult to substantively change, let alone consolidate or close them down.

During the first two decades of China's rapid economic reform (1980-2000), structural energy conservation accounted for approximately 70 percent of total energy conservation.[21] However, between 2003 and 2004, the energy conservation rate (rate of decrease in energy intensity) has turned negative, a rather rare phenomenon. This is most likely due to the excessive growth in production of energy-intensive industries such as steel, cement and aluminum, yet it holds the possibility that structural energy conservation is declining. This would be extremely unfortunate, since in the long run, there remains potential for huge gains in structural energy conservation.[22]

Accelerating technological innovation clearly brings substantive drops in energy consumption per unit output. There are numerous examples of China's development in advanced science and technology. To name a few, China has independently designed and manufactured 600MW supercritical pressure units, [23] 320kVA (kilo Volt-Ampere) roasters for aluminum processing, [24] and new high-volume pre-heaters for the cement-making process. In 2005, high-efficiency electric light sources accounted for over 50 percent of the total of electric lighting.[25] Yet, only 30 percent of China's energy conservation achievements from 1980 to 2000 were the result of technological progress illustrating - in stark relief - how much room remains for these advances to achieve big leaps in China's energy conservation.

The Policy Report Card

Research by the World Bank has shown that 'market forces' only contribute to approximately 20 percent of energy conservation. [26] This is primarily because there are substantially more 'market obstacles' and fewer economic incentives to achieving permanent energy conservation gains than for instance, increasing energy supply through development projects. The latter is largely responsive to market mechanisms such as price, quantity and technological innovation. For energy conservation, on the other hand, the role of the market is constrained because markets and prices tend to represent short term profits but do not sufficiently reflect long term benefits and potential. As a result, energy conservation is generally unattractive, especially with investors only willing to make a minimum investment. In addition, the market fails at incorporating the impact of environmental degradation in the cost of energy consumption, thus negating an important incentive to changing consumption behavior and promoting conservation.

The government is therefore essential to overcoming negative externalities like environmental degradation and can do so through managing energy conservation such as using energy-efficiency standards, tax and funding incentives, energy audits, market regulation and research and development initiatives. However, this brings us to the one of the biggest obstacles facing the promotion of energy conservation: institutional weakness. Already more than 10 years ago, the government set out the guidelines on energy policy that put conservation on a par with resource development, even making the former a priority. Yet, it is clear this goal is far from being realized.[27]

Agencies

While market-oriented reforms in China have pressed forward in the past decade, energy conservation work has noticeably retreated. The government administration for energy conservation has been losing a significant amount of its personnel since 1992 and nearly all economic incentive policies arising from it have been abolished.[28] With recent energy shortages, these institutional shortcomings are all the more glaring. In comparison with areas such as power and fossil fuels, the investment in energy conservation is anemic. Set alongside similar agencies in other market economies, there is an urgent need for reform of this government body. Take the United States for example. In 2003, the Office of Energy Efficiency & Renewable Energy (under the Department of Energy) had a staff of 450 and a budget of $1.3 billion. Japan's equivalent bureau had 65 employees and a budget of $400 million. [29] China has only a handful of people working on energy conservation with a fraction of the budget. [30]

A case in point of the negative effect of administrative and regulatory inadequacy is the current status of China's Energy Conservation Law, promulgated in 1998. Approximate evaluation suggests that only 6 percent of its articles have been implemented sufficiently, 60 percent have been poorly implemented and 34 percent have not been implemented at all. [31] One article within that law covering energy conservation design standards for buildings has been adopted by roughly 15 to 20 percent of new buildings in cities and towns in China. It is urgent that the Energy Conservation Bureau is reestablished and the system of an executive energy conservation meeting of the State Council resumed. Government officials at all levels should greatly strengthen their abilities in comprehensive decision-making, coordination and administration of energy conservation.

Investment

Reducing the growth of energy consumption has been shown through research to be highly dependent on the amount of investment put into energy conservation. In 1983, 13 percent of total energy development investment went into energy conservation. That figure fell to 4 percent in 2003. Lowering energy consumption levels to half of GDP growth would take an estimated 10 times the investment of current levels.[32]

Investment in technological innovation is probably the most important factor in altering energy conservation levels. In China, there are very few R&D funds available for energy conservation technology. Enterprises are usually the main source of innovation, yet this remains small to non-existent in many sectors of the economy. One survey conducted by the Ministry of Science and Technology reveals not only is enterprise R&D funding in China far below their developed economy counterparts, a mere 2 percent of the latter's total R&D funding went to energy conservation.[33] In similar fashion, a negligible 0.66 percent of enterprise expenditures went to new product development.[34]

Government R&D in energy conservation is equally deficient. It invested a total of 609 million RMB ($73 million USD) on energy R&D, with an estimated 10 percent of that going toward energy conservation. [35] This figure pales in comparison with others, such as the United States and Japan. They spent $557 million and $559 million respectively on energy conservation, comprising 23.8 percent and 15.7 percent of their respective total energy R&D funding. [36]

The lack of funding and policy oversight goes beyond economic constraints. It is an attitudinal issue as well. If the government is to make any dent in energy conservation technology innovation, it must significantly increase funds for energy conservation R&D, guide and encourage enterprises to develop energy conservation technologies and promote the publication and dissemination of research results.

Incentives

China's fiscal and tax reform of 1994 effectively undermined many of the incentives for the promotion of energy conservation that were built into previous policies. [37] The adverse effect on conservation has been grave indeed. Government support is vitally important in overcoming the many obstacles to energy conservation that currently exist in all the processes of the product life-cycle and in all actors relevant to energy conservation. This government action comes mainly in the form of financial and tax policy incentives and can be divided into several categories. The first category is comprised of those policies that promote energy conservation by lowering its investment cost such as financial allocations, tax reductions or exemptions and preferential loans. Another group entails measures that increase the cost of energy consumption, for example energy and environmental protection taxes. A third purview of government action comes in strengthening market signals by managing prices that reflect an accounting of various externalities. Taken together, these government tools are essential components for managing energy demand, implementing voluntary conservation agreements and energy audits of companies and promoting energy efficiency standards.

One of the most useful measures at the government's disposal is a variety of levies and/or exemptions that curb consumption of fuel or encourage energy efficiency. The main goal of highway transportation tax is both for energy conservation and environmental protection. A suitable level of fuel oil tax plays an important role in oil conservation. In 2003, the U.S. gasoline fuel oil tax was only 11 percent of the British rate, while the average daily oil consumption per person in the United States was 2.6 times that of Britain.[38] The European Union levies vehicle tax by engine power and encourages consumers to buy small displacement cars. In 2005, to encourage the development of high-efficiency and clean automobiles, Japan lowered the vehicle

Failing to Set an Example

If a government has any role in being a model for energy conservation, then China's is doing a poor job. Defined as all administrative institutions, enterprise activities, and social organizations that fall under the auspices of the state, the Chinese government encompasses approximately 50 million persons. This is a bureaucracy on a grand scale and, unfortunately, it also wastes energy on a grand scale.

In 2003, the government's per capita use of energy, and of electricity in particular, was 7.6 and 10.9 times higher, respectively, than China's urban per capita energy consumption. In the same year, energy consumption by the Chinese government was recorded at 63.35 million tons of coal and 91.1 billion watts of energy, an amount that surpassed the total energy consumed by China's 800 million rural population. These levels of energy consumption are also far higher than other governments. In one comparison, for example, the government of Australia's New South Whales province is 2.3 times lower than that of China's.

Rather than have society's highest rate of energy consumption, the government should strive to be a model for energy efficiency, or at the very least, no more wasteful than the citizens it governs. It has the means and responsibility to be an exemplar in the implementation and organization of energy efficiency and conservation policies as well as follow its own mandate of purchasing energy efficient products and technologies. The Chinese government has yet to meet that challenge.

tax by 25 percent to 50 percent for new automobiles that meet fuel economy and emission standard targets set for 2010. For those who buy hybrid power or fully electric automobiles, the government offers subsidies as high as 50 percent of the price difference between these automobiles and conventional gasoline automobiles. [39]

As a second example, energy pricing management is also a powerful instrument of the government to promote energy conservation. The basis for improving energy efficiency in the economy remains using the price of energy to fully reflect the total cost of energy; that is, allowing the supply and demand relationship to function properly. Under these conditions, energy price and energy conservation are directly linked: constant energy prices may lead to improvement in efficiency but will also lower energy expenses thereby increasing demand; on the other hand, a rise in energy price will reduce demand and promote R&D of energy conservation technology. [40]

Energy efficiency can also be effectively enhanced using standards labeling. An example of this activity is the 'Energy Star' label adopted by the U.S. government, which it supported with $35 million in 2001. [41] Expanding the market share of energy-saving products through the lowering of market barriers is another method of promoting energy efficiency. The governments of 40 different states and utility companies subsidized customers with $63 million for purchases of various home appliances. In California, a subsidy was implemented in the amount of $75 to $125 per refrigerator, $50 per air conditioner and $75 per washing machine, if they met energy-saving standards.[42]

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Economic incentives can come from a variety of sources including the government budget, energy companies, energy conservation funds and international cooperation projects. Thailand has set up one of the world's largest energy conservation funds, totaling $5 billion, through various means including levies on oil products. [43] The fund promoted energy efficiency through labeling, demand side management and voluntary agreements. During the 1980s, China established several national energy conservation special funds, which offered preferential interest rates for technology innovation, but they were all abolished by 1998. [44] Currently, there is a dire lack of government administration funds for energy conservation. Most of the major conservation projects rely on international cooperation. While some international cooperation projects have achieved good results, they are not sustainable without robust domestic incentive policies.

Information

Implementing effective energy conservation policies requires a comprehensive understanding of China's increasingly complex energy consumption patterns. This encompasses statistics and data coverage as well as accurate indexing, all of which are particularly deficient at the present time.

Other information regulation and services should be provided including public campaigns, information networks, education and consulting services. Guiding companies to execute voluntary energy audits have been highly effective in other countries and this practice should be aggressively adopted in China. Both the U.S. federal and state governments and the Japanese Ministry of Economy, Trade and Industry provide small- and medium-sized enterprises with free energy audits. Through energy auditing, U.S. industrial enterprises have reduced their electricity consumption by 2 percent to 8 percent. Power companies provide energy audit services for energy conservation in residential houses, with an average energy conservation rate of 3 percent to 5 percent.[45]

A Change of Heart Needed

Energy conservation provides a crucial framework for understanding China's energy security strategy. In order for this to become a reality, however, a fundamental shift in how the nation perceives energy consumption and conservation is necessary. During the era of the planned economy, energy conservation was thought of as bridging the gap between energy supply and demand. Quota setting and price fixing were used to coerce people to conserve energy during shortages and thereby bring demand in line with supply. However, once those energy deficiencies were met and the crisis ended, conservation measures were relaxed, and previous consumption levels reappeared. The result was that following a period of energy scarcity, a phase of increased energy consumption was effectively causing a reversion to low energy efficiency.

Although such policies act to curb demand-side behavior, they do not place the decision-making in the hands of the consumer. Rather, the thinking underlying this planned economy strategy, much of which still exists today, effectively puts the emphasis of energy consumption levels and conservation on the supply and development of energy. In other words, it stresses the need for increasing supply rather than decreasing consumption. The reasons for this are complex, but a key element is that as long as the monopolistic energy companies and the government have a deeply integrated relationship, the management of energy supply will trump control of energy demand. Such companies, focused on supply and development, will naturally have countervailing interests to energy conservation and efficiency.

Altering this reality will require a fundamental shift in attitude of the government and its energy administration from predominantly pursuing supply quantity through energy exploitation and production to expediting conservation through economic and market mechanisms. The International Energy Agency states that, "the supply and demand relationship in the energy system is not determined primarily by energy supply, trade or energy markets but by end energy services." This transformation cannot be accomplished solely through technological, policy and institutional improvements, but also requires profound changes in people's values. This is particularly relevant to China, whose consumption behavior has yet to catch up to the realities of China's energy situation. Enforcing energy conservation would stir a revolution that will truly change the landscape of China's energy consumption and hence its energy security.

Notes

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Energy conservation is reducing the amount of energy used for different purposes. This may result in an increase of financial capital, environmental value, national and personal security, and human comfort. Individuals and organizations that consume energy may conserve energy to reduce costs and promote economic, political and environmental sustainability. Industrial and commercial users may want to increase efficiency and thus maximize profit.