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Viewpoint

Market-driven energy pricing necessary to ensure China's power supply

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ABSTRACT

China's rapid economic growth has strained its power supply, as manifested for instance by the widespread 2008 power shortage. The cause for this shortage is thought to be the current Chinese energy pricing system, which is mainly government rather than market controlled. Government-regulated price-caps for coal have seriously affected coal supply. At the same time price-caps for electricity supply have caused suspension of power plant operation. As a result, the average operating time of coal-fired power plants declined 50 h annually across the nation in the first half of 2008 compared to the previous year, despite clear power shortages. Here, it will be suggested that energy pricing, set by supply and demand may effectively discourage excessive growth in heavy industry, substantially encourage energy conservation and efficiency, and curb the rapid electricity demand in China. It will be argued that a market-oriented electricity pricing mechanism is required for China to secure its future power supply.

1. Introduction

China's economic growth in the last years has been the fastest in the world, being on track to record its fifth straight year of double-digit growth in gross domestic product (China Statistical Yearbook-2008, 2008). Accelerating development of industrialization and the growing pace of urbanization have challenged China's energy supply in particular its electricity supply. The past five years have witnessed two severe electricity shortages in China. The first one started in 2003 and extended to 2004. In 2004, a total of 24 provincial areas experienced power brownouts, the power deficit amounting to 10% of the installed capacity (Xinhua, 2004b). China suffered another power shortage in 2008, a total of 19 provincial areas experiencing power brownouts (China National Development and Reform Commission, 2008).

Further industrialization and urbanization are the linchpins for China to modernize its economy, both requiring an adequate supply of electricity. To ensure such electricity supply, approximately 100 GW of new installations have been established annually in recent years (Jiang, 2008)—roughly the equivalent of Thailand and the UK's total capacities combined (Wasser, 2007). Despite this enormous effort, the 2008 power shortage shows that only increasing power capacity does not suffice to ensure adequate power supply.

This paper is structured as follows: firstly, some background information will be provided concerning Chinese power generation: secondly, the main reasons for the 2008 power shortage will be identified; and finally, policy recommendations will be proposed to ensure future Chinese power supply.

2. General status of China's electricity

The total in place capacity of China's electric power reached 713 GW in 2007: 554.42 GW from coal, 145 GW from hydro, and 8850 MW from nuclear (see Fig. 1). The energy sources and sinks tend to suffer from geographical mismatch between supply and demand, coal being concentrated in the North, hydro concentrated in the Southwest and middle, and only nuclear energy being concentrated in the high-usage area as shown in Fig. 2.

Construction and development of power grids in China tend to be sluggish. The seven individual grid systems function well but their interconnectedness not, resulting in an insufficient inter-grid electricity exchange capacity (see Fig. 2). From 2002 to 2007, investment in generation capacity increased from Rmb 74.7 billion (US$ 9.0 billion) to Rmb 322.6 billion (US$ 42.2 billion) at an average annual increase of 28%. At the same time, investment in grids annually increased only by 9%, from Rmb 157.8 billion (US$ 19 billion) to Rmb 245.1 billion (US$ 32.25 billion) (Fenby and Qu, 2008). China lacks a unified power grid network across the nation and plans to set it up by 2020 (People's Daily, 2000).

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In China, the State takes the principal policy decisions regarding electricity. At the national level, the responsibility for policy decision regarding electricity is supposed to reside with the State Electricity Regulatory Commission (SERC), an ostensibly independent regulator established under the State Council in 2003. As of to date, spring 2009, the National Development and Reform Commission (NDRC) has refused to yield key tools to SERC, including the authority to determine prices (see Table 1) and approve new capacity installations, preventing SERC from fulfilling its mission.

3. Energy price regulation blamed for power shortage

3.1. Rapid growth of power supply capacity

The Chinese government did not approve any new large-scale power station from 1999 to 2002. This resulted in inadequate power-installed capacity and caused extensive shortage of electricity in 2004 (Li and Yu, 2005; Lin, 2005). This power shortage stimulated a sharp rise in new power station construction across China since 2004 (Xinhua, 2004a), most of them coal-fired plants. China brings two additional coal-fired power plants to the electric power grid every week, 361 plants between 2002 and 2006 Kater et al. (2007). As mentioned previously, approximately 100 GW of new installations of electric power every year is generated (Jiang, 2008), roughly the equivalent of Thailand and the UK's total capacities combined (Wasser, 2007). China had 380 million kilowatts of installed power generating capacity by the end of 2003. By the end of 2007, the installed capacity of electric power reached 713 GW (China Electric Power Yearbook-2008, 2008). In 2010 the installed capacity of electric power in China will reach or exceed 900 GW and is likely to become the largest electric power system in the world (Jiang, 2008). Thus Chinese electricity output has risen from 1910.6 GWh in 2003 to 3271.2 GWh in 2007 (China Energy Statistical Yearbook-2008, 2008) (see Table 2).

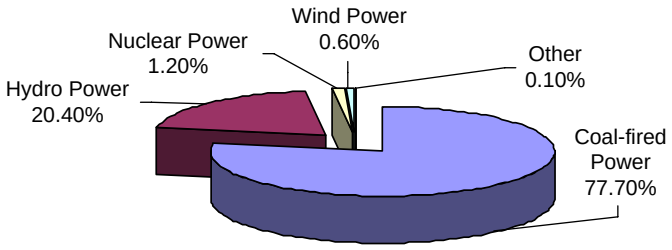

Fig. 1. China's partitioning of electric power generation in 2007 (China Electric Power Yearbook-2008, 2008).

Table 1
China's energy pricing mechanisms (Zhang et al., 2006).

Coal	The price of coal for power plants is guided by the NDRC, the other by market mechanism.
Electricity	A two-part tariff is implemented: the capacity power price to the electricity transmission market is determined by the NDRC; the electric power price is mainly regulated by NDRC.
Oil	NDRC determines the domestic benchmark price according to the international average price of analogous crude oil the previous month; both buyer and seller agree on a discount depending on oil quality and transportation distance.
Refined products	NDRC determines the domestic retail benchmark price according to the average price of the previous month in Singapore, New York, and Rotterdam, allowing an 8% fluctuation o.
Natural gas	NDRC determines ex-factory and pipeline transportation prices according to different customers, whereas local government determines the urban end users' charge.

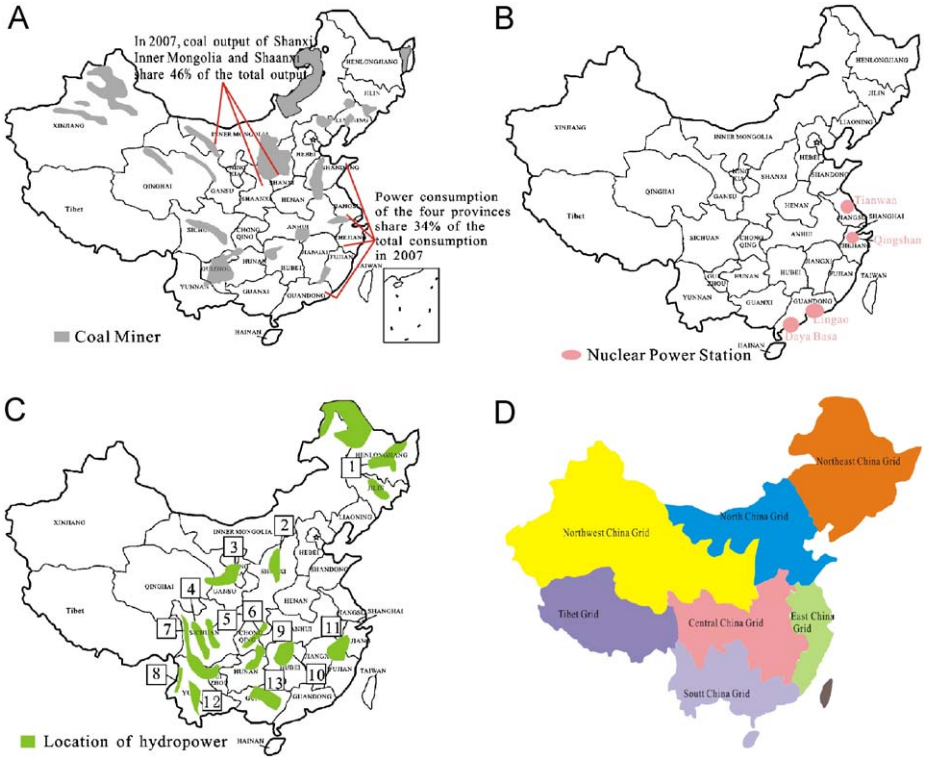

Fig. 2. (A) the location of coal miner and main power consumption; (B) the location of nuclear power, (C) the location of hydropower basis; (D) China's seven grid (China Electric Power Yearbook-2008, 2008; China Energy Statistical Yearbook-2008, 2008; Fenby and Qu, 2008).

Table 2
Output and consumption of China's electricity and coal from 2000 to 2007 (China Energy Statistical Yearbook-2008, 2008).

Item	2000	2002	2003	2004	2005	2006	2007
Total Electricity output/GWh	1355.6	1654	1910.6	2203.3	2500.3	2865.7	3261.5
Thermal power/GWh	1114.2	1338	1580.3	1795.6	2047.3	2369.6	2722.9
Hydropower/GWh	222.4	287.9	283.7	353.5	397	435.8	485.3
Nuclear power/GWh	16.7	25.1	43.3	50.5	53.1	54.8	62.1
Total electricity consumption/GWh	1347.1	1646.5	1903.2	2197.1	2494	2858.8	3271.2
(I)Final consumption/GWh	1253.4	1529.6	1777.1	2055.1	2323.4	2672.9	3065
Industry/GWh	871.7	1075.8	1263.9	1483.4	1677.5	1938.9	2256.9
(II)Losses in transmission/GWh	93.7	116.9	126.1	142.1	170.6	185.9	206.2
Total Coal output/million ton	1299.2	1454.6	1722.0	1992.3	2204.7	2373.0	2526.0
Coal for power generation /million ton	558	686	819.7	919.6	1032.6	1187.6	1305.5
Coal for power/total coal output (%)	42.9	47.2	47.6	46.2	46.8	50	51.7

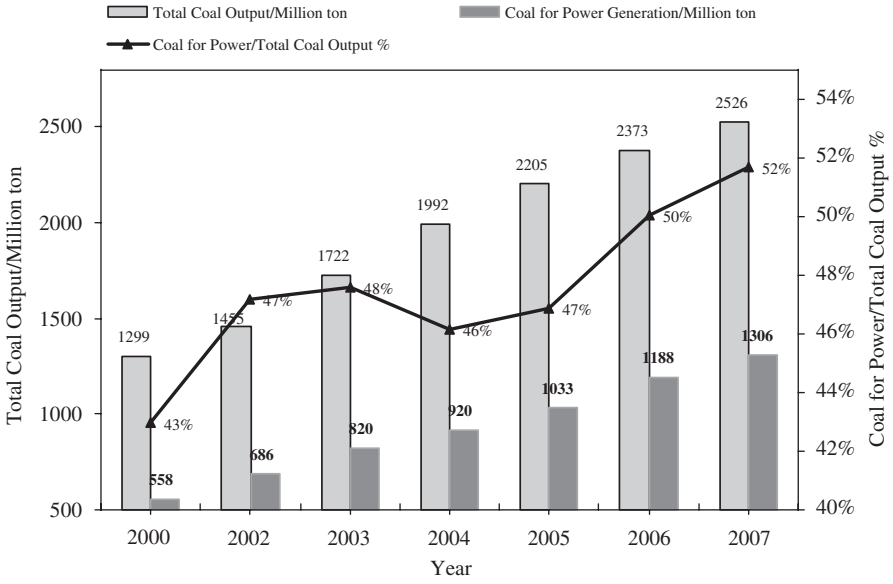

Fig. 3. Chinese coal output from 2000 to 2007 (China Energy Statistical Yearbook-2008, 2008).

3.2. Rapid growth of coal output

About 80% of China's electricity comes from coal-fired plants. To fuel its coal-fired plants, China's coal industry has witnessed high-speed growth since 2003. China's raw coal output has increased by 804 million tons from 2003 to 2007, reaching 2526 million tons in 2007 (China Energy Statistical Yearbook-2008, 2008), accounting for approximately 40% of the world's total (Jiang, 2008). The percentage of coal for power increased from 47.6% in 2003 to 51.7% in 2007, from 819.7 million tons to 1305.5 million tons (China Energy Statistical Yearbook-2008, 2008) (see Fig. 3). The raw coal output across the nation reached 1.26 billion tons, increasing by 14.8% in the first half of 2008 compared to 2007 (State Information Center of China, 2008).

3.3. Decreased in elasticity of electricity consumption

Our empirical study uses the time series data of growth rate of GDP and electricity consumption for the 2000–2007 period for China. The growth rate of GDP and electricity consumption data for China are obtained from the National Statistic Yearbook (China Statistical Yearbook-2008, 2008), and the China Energy Statistical Yearbook (China Energy Statistical Yearbook-2008, 2008). Fig. 4 represents graphically the growth rate of GDP, the growth rate of electricity consumption, and the elasticity of electric consumption. Notice that according to Fig. 4, the elasticity of electricity consumption (defined as the ratio of the growth rate of electricity consumption and the growth rate of GDP) in China reached 1.56 in 2003, the year when the power shortage occurred and decreased in later years. The elasticity of electricity consumption in 2007 fell to 1.21. In 2008, China's GDP growth was 9.0% (Xinhua, 2009). According to the elasticity trend of electricity consumption shown in Fig. 4, the growth rate of electricity demand in 2008 is less than that in 2007. It can be estimated that electricity demand in 2008 has not increased abnormally and obviously by the trend of elasticity of electricity consumption. Power-installed capacity, coal production, and electricity demand should, therefore, not be blamed for the power shortage in 2008.

3.4. Price-cap regulation creating power shortage

At present, the government still regulates the prices of such important energy sources as oil, natural gas, and electricity. Only the price of coal is determined to some extent by a market mechanism (see Table 1). Such energy pricing mechanism fails to

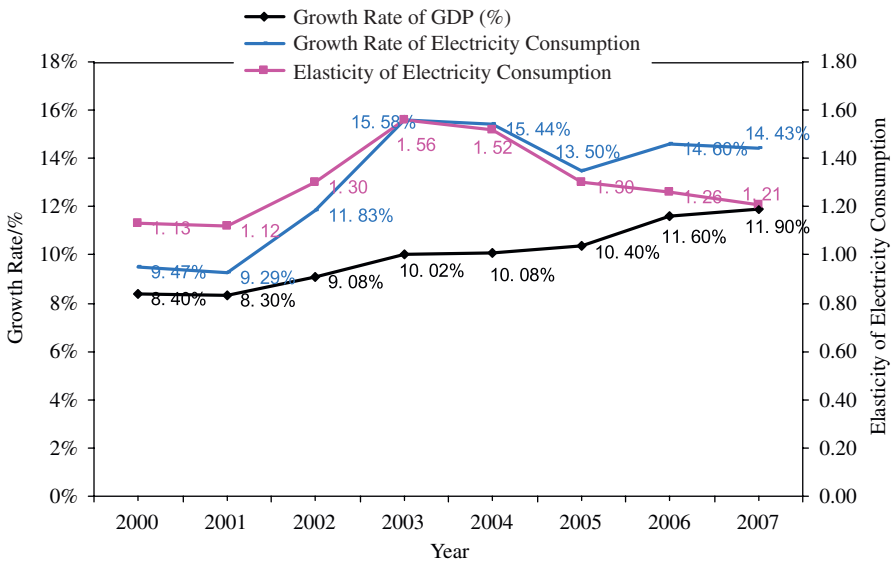

Fig. 4. Growth rate of electricity consumption, growth rate of GDP, and calculated elasticity of electricity consumption (China Energy Statistical Yearbook-2008, 2008; China Statistical Yearbook-2008, 2008).

fully reflect the scarcity of resources, their supply, and demand, and the environmental cost (China State Council Information Office, 2007). Government-set energy prices have distorted the relationship between the cost of power coal and that of electricity generated, discouraging power generation.

3.4.1. *Artificially distorted prices causing coal shortage*

Coal producers are unwilling to supply fuel to power plants because of coal price-caps. The reason is a significant price difference between coal sold to power plants and coal sold for other industrial or household activities: the price of the former is controlled by the government, of the latter by market. As the price of coal for other uses continued to rise in recent years, this price difference has been exacerbated, increasing from Rmb 33.3 Yuan (US $ 4.9)/ton in 2003 to Rmb 156.2 Yuan (US $ 22.9)/ton in June 2008, even reaching occasionally Rmb 200 Yuan (U.S $ 29.4)/ton (Xinhua, 2008). Clearly the incentive to sell on the open market is huge and results in the inadequate and low-quality supply to power plants.

The coal-rich Shanxi Province in northern China is a good example. In 2008, coal production in this province will reach 680 million tons, up to 9% compared to a year earlier. However, power plants with a capacity of 3.5 GW, accounting for 15.2% of the total electricity output, halted production because of coal shortage according to Shanxi Province Electric Power Association (Wan, 2008). The reason coal mines are unwilling to sell coal to power plants is the above-mentioned government-regulated low price for power-designated coal. Shanxi province, producing one-fourth of China's coal, has therefore suffered 4.6 GW of power shortages for lack of power-designated coal, the highest level recorded in recent years (Wan, 2008).

Statistics show that major power plants connected to the State Grid had less than 3–4 weeks worth of coal stocks, this being the international norm. A third of these plants had less than a week's worth of coal stocks, whereas 12% of them had only a three day supply. A total of 58 generators had been shut down due to lack of coal (Bai, 2008a).

3.4.2. *Price-cap regulation of power discourages power generation*

China's power companies have been pinched by the widening gap between increasing production cost and relatively low, government-controlled prices they can charge for power. Chinese coal-fired power plants have long asked for reform of the energy pricing mechanism, linking electricity prices with actual production cost. The government reacted to the appeal in the electricity sector in 2004, deciding to review electricity prices every six months and adjusting them if necessary (China National Development and Reform Commission, 2004). This mechanism, however, has been implemented only twice in the past three years for the following two reasons: firstly, governmental concern about electricity price hikes translating into a spurt of consumer inflation; secondly, rising electricity costs dealing another blow to the manufacturing sector, already suffering from weakening overseas demand, rising labor costs and the rise of China's Yuan currency. Over the past year, China's government has managed to hold down electricity prices to rein in inflation and to increase the international competitiveness of the manufacturing sector. This electricity price-cap has led to non-profitability of electricity producers, compelling them to suspend part of their operation.

Shandong province in east China, a long-time electricity supplier for neighboring provinces, is a good example. Shandong survived previous nationwide power shortages due to contributions to its grid by provincial and company power plants. However, this does not suffice any longer. The local grid announced a maximum summer power shortage of 8.82 GW, or 20% of its generating capacity connected to the local grid (Bai, 2008b). The reason for the power shortage is a too small or even negative marginal profit that forced output reduction with concomitant power shortages. The squeeze experienced by the local power plants between increased costs and government-controlled electricity price, induced them to cut back on electricity generation using a variety of excuses, such as closing plants for maintenance. In the first five months of 2008, the 179 power plants in Shandong province suffered a loss of 3 billion Yuan (US $ 441 million), because of controlled electricity tariffs (Wang, 2008). The more power a plant produced, the higher the losses plants might suffer, so a total of 15.54 GW of generating capacity, or 35.72% of capacity with grid connections, had been idled in Shandong Province (Bai, 2008b).

Similarly, the average operation time of coal-fired power plants across the nation declined 50 h annually in the first half of 2008 compared to a year ago, despite power shortages, according to the

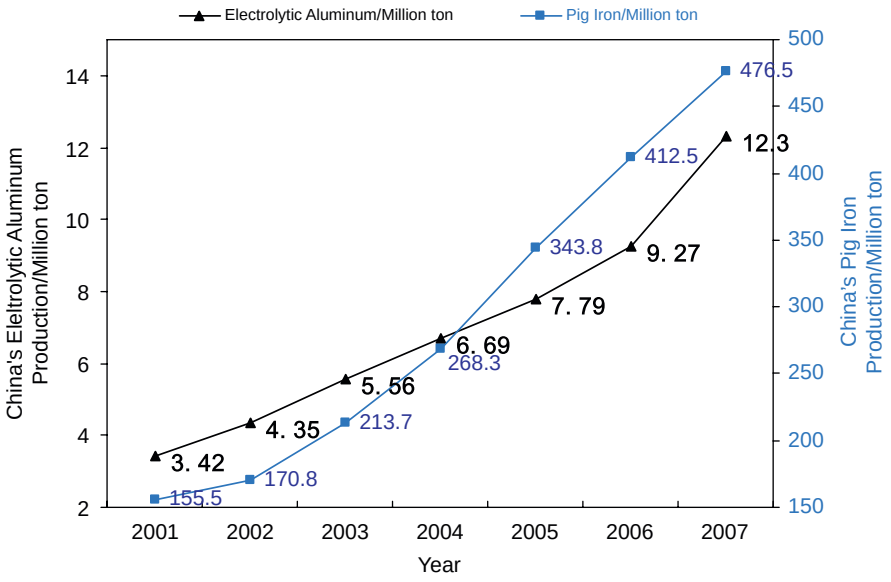

Fig. 5. Output of China's electrolytic aluminum and pig iron from 2001 to 2007/million ton (China Statistical Yearbook-2008, 2008).

China National Development and Reform Commission (Wang, 2008).

These examples suggest that keeping electricity prices down artificially, will exacerbate power shortage. China's policy makers should deregulate electricity and let the market set power prices. If not, the state's relationship with its coal miners and power firms is at risk—it becoming a struggle to encourage reluctant mine operators to supply fuel to power plants and to urge disinclined generators to fire up to avoid recurrent power shortages caused by its pricing policy.

4. Market forces curb rapid electricity growth in demand

To secure Chinese power supply, it also should curb the rapid growth in demand for power in China. From 2003 to 2007, electricity consumption of China has soared by 78%. In 2003, electricity consumption of China was 1903 GWh; almost doubling in 4 years to 3271 GWh in 2007 (see Table 2). This surge in Chinese electricity demand will continue unabated. It is projected that China's electricity demand will touch 3810 GWh by 2010 (State Grid Corporation of China, 2007). The electricity price marketization may effectively decrease the rapid growth in electricity demand.

4.1. Discouraging heavy industry

According to data of National Bureau of Statistics of China, industry accounts for more than 70% of the total electricity demand (Table 2). Heavy industry, such as iron and steel manufacture, non-ferrous metals, and construction material industries are the biggest consumers.

The low electricity price, kept down by government regulation, has resulted in China's recent growth of heavy industry with large over capacities. Take the electrolytic aluminum industry and steel industry as example. The cost of electricity accounts for nearly one-third of the production cost of aluminum. Stimulated by the low electricity price, the output of electrolytic aluminum has increased from 3.42 million tons in 2001 to 12.3 million tons in 2007 (Fig. 5), one-third of the world total. The steel industry is electricity-intensive, using up about 19% of the global industrial energy usage (OECD and IEA, 2007). Similarly, low energy prices

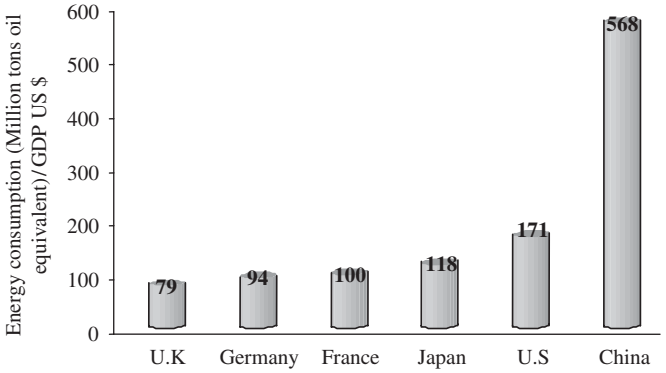

Fig. 6. China's unit GDP consumption compared with that of selected developed countries. Energy consumption from (BP, 2008); GDP from (World Bank, 2008).

fueled China to become the largest producer of steel in the world (Haley, 2008), accounting for 36.4% of the global output in 2007 (IISI, 2008). In 2001, the output of China's pig steel was 155.5 million tons. In 2007, the figure reached to 476.5 million tons (China Statistical Yearbook-2008, 2008). In just 7 years, China's electrolytic aluminum production and steel production have increased by 3.6- and 3.1-fold, respectively (see Fig. 5). The low electricity price caused the heavy industry consumptive splurge and exaggerated the pressure on electricity demand. Marketization of the electricity price causes a rise in electricity price that effectively discourages excessive growth in the heavy industry, and thus curbs effectively China's growth in electricity demand.

4.2. Encouraging energy conservation and efficiency

The low electricity price set by government also has led to inefficient use of energy, because low price encourages China's firms to invest in cheaper equipments and technologies with lower energy efficiency. The amount of energy China uses to create one US dollar worth of GDP is 3.3 times that of the United States, 4.8 times that of Japan, and 6 times that of Germany (see Fig. 6). Price leverage is still the most effective way to improve energy efficiency. Earlier studies by Fan, et al., show that energy efficiency is closely related to its price, and energy pricing

subject to supply and demand contributes substantially to energy-efficiency improvement Fan et al. (2007). Price is also the best way to save energy. High prices have pushed down US oil consumption by about 0.1% in 2007 (BP, 2008) and nearly 4% in the first half of 2008 (EIA, 2008). Put on a per capita basis the reduction in oil usage is even larger, since the US population grows by about 1% per year.

As long as low energy prices are government set, enterprises will lack the drive to improve efficiency and consumers will lack the drive to save energy. It is therefore necessary to reform the pricing mechanism, deregulate the electricity market and let prices guide investment of enterprises as well as individual consumption. In this way, China's rapid growth in demand for electricity will be abated

4.3. A lesson from Iran

The energy shortage caused by energy price-cap occurs not only in China, but also in other countries, such as Iran. Iran has the second largest oil reserve in the world, and is the fourth largest producer of crude oil in the world (BP, 2008). Inadequate refining capacity is the major weakness of Iran's oil and gas industry. The Iranian government imports large quantities of gasoline as well as natural gas – 41% of its total consumption – to meet its domestic demand. To make matters worse, Iran spends nearly $30 billion annually on subsidizing oil and gas to domestic consumers. Low oil price stimulated car production and sales boom in Iran. Iran is in regional terms a major car producer with a million units a year produced, though many of the nation's vehicles are of outdated design and not fuel efficient. Skyrocketing local consumption, as well as a huge illicit trade in subsidized fuel particularly across to Afghanistan and Pakistan, have nibbled at fuel stocks. Iranian fuel is also found in Turkey and Iraq where the price per liter is up to 12 times higher. As a result, Iran had to choose to impose full fuel rationing in the Jun, 2007. Private motorists were allowed to purchase just 100 l a month (NSCS, 2004).

5. Conclusion

Reforming energy price mechanism and energy pricing marketization serve a double purpose. It is an optimum way to not only avoid energy shortage but also to ensure an energy supply in the future. China's government should advance energy pricing reform in a vigorous yet steady way, gradually established a natural market-based pricing mechanism that intrinsically reflects resource scarcities, changes in market supply and demand, and environmental costs. The ramifications of price increases in the energy sector should be seriously considered. On the one hand, increased power costs adversely impact the economy in difficult times of economic turbulence as the current one in which industry is facing unprecedented downsizing. On the other hand, power tariff hikes will undoubtly cause hardship for the poor, requiring some differentiation between industrial and private demand.

As far as reforming China's coal and electricity pricing mechanism, three policy measures are suggested in this paper: firstly, coal price reform to realize all-round marketization i.e. price of coal for power plant and other usage set by the market, secondly, removal of an electricity tariff to ensure that electricity generation and selling prices are eventually formed in accordance with market competition. As a proper power grid is the foundation and carrier of the power market, the construction and development of power grid to cultivate the national market, will have as principal effect market regulated power supply and demand finally, differential tariffs for industry and needy households – if well-devised and time-limited – should be developed in reform of the electricity pricing mechanism to prevent increased energy prices to affect needy households detrimentally.

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