Rural Electrification in China 1950-2004

Historical processes and key driving forces

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I. Introduction

Since 1949, rural electrification in China has expanded rapidly, contributing to the sustained and steady development of the agricultural sector, rural economy and quality of life for rural households. China introduced electricity access to over 900 million rural residents in just over 50 years and achieved an electrification rate as high as 98% (Barnes and Foley, 2004).[1] Many factors have contributed to the success of China's rural electrification; small hydropower has played a particularly large role in remote rural regions.

The historical process of rural electrification in China can be divided into three stages. The first stage lasted from 1950 until the end of 1970s, when policies of economic reform and liberalization were introduced. Rural electrification was slow, yet impressive progress was made under strict central planning. The second stage encompasses the last two decades of the 20th century, during which time rural industrialization proceeded full force, with investment mainly from local rather than central government. The third stage began at the turn of the century and included large scale consolidation and upgrading of rural grids, funded by a variety of sources. This further improved the quality of electricity service and extended access to remote rural corners of the country. The process of rural electrification has now neared its end, having become almost fully integrated into the power sector in China.

[1] China Power Yearbook (2003). The numbers from different sources vary greatly and no attempts are made to harmonize the sources. In general statistical information is consistent with the overall trend of rural electrification in China. For further information, the numbers are given in tables in appendices. For the sake of simplicity, data availability, and lack of policy influence, data and discussion in this paper do not cover Taiwan, Macau and Hong Kong.

This report is structured as follows. Part II provides an overview of rural electrification in China today. Part III reviews the historical process of rural electrification. Part IV presents the key forces driving China's rural electrification effort. Part V examines the future prospects of rural electrification in China.

II. Overview of Rural Electrification in China

Access to electricity is key to the development of rural China.[2] Rural electrification in China is unique in many respects due to the diversity of natural, economic and social characteristics. While one must look at both access to electric power and the quantity of electricity consumption—and this paper indeed discusses both—our principal focus is the rapid increase in access.

2.1 High rate of access to electricity but low rate of household consumption in rural areas

As a developing country with an average income level of around US$1000[3] per capita, China has realized a high rate of electricity access in rural areas. In 2002[4], rural

[2] The definition of rural in China is complicated. Before 1978, the non-agricultural population in counties in China was very small, with industrial sectors undeveloped or under-developed. In contrast, *cities* were typically dominated by industrial and service sectors with a small proportion of agricultural population in the suburbs. Conventionally, the definition of rural areas is given by county and below county, an administrative and geographical region in which all the population, all the sectors and economy were considered rural part of the economy. This definition is used by the Ministry of Agriculture and the Ministry of Water up to now. However, the China Statistical Bureau (NSB) does not use this definition in their reporting. Employment and current residence are the source of information in NSB reporting. In many counties, industrial sectors are highly developed and therefore, non-agricultural enterprises in these counties are counted as urban/non-agricultural in NSB statistics. For the purposes of this paper, we have tried to consistently use the term "rural" only when data comes from the NSB. Data from other sources is identified as "County-level and below." The latter would include major county towns and industrial enterprises. The term "rural" is also used when making general references to more rural areas of China (though these could include county-towns). This confusion is, unfortunately, unavoidable, given the varying definitions.

[3] $1100/c for 2003 using exchange rate but $5003/c using PPP for the same year. See UNDP (2005, p. 267).

township, village, and household electricity access rates were, respectively, 98.54%, 98.71%, and 98.48%. Nationwide, in 2350 counties the township electricity access rate was 100%; in 2112 counties the village access rate was 100%; in 2111 counties the access rate of rural households was over 95%; and in 78 counties the access rate was less than 50%. In 2002, only 3 counties, 608 townships, 9303 villages, and 4.58 million rural households—1.2% of the total population or 2% of the population at the county level or below—lacked electricity access (China Electric Power Yearbook 2003).

In 2004 per capita electricity consumption in rural areas was 127 kWh, compared with 270 kWh in urban areas. And this number may be an overestimate if we look at the use of electric appliances by rural and urban households (see table 1), as use of electricity for productive purposes in rural homes is counted as household consumption (rural residents' income is only 30% of their urban counterparts.)

Table 1 Electric appliances in rural and urban households (per 100 households)

	1980		1990		2000		2004	
	rural	urban	rural	urban	rural	urban	rural	urban
Washing machine	1.9	48.3	9.1	78.4	28.6	90.5	37.3	95.9
Refrigerator	0.1	6.6	1.2	42.3	12.3	80.1	17.8	90.2
Air conditioning	0	0	0	1.1	1.3	30.8	4.7	69.8

Source: China Statistical Yearbook, various years, 1980-2005.

2.2 Modes of Rural Electricity Supply

Unlike other developing countries, China has a policy to encourage small rural power stations to develop their own electricity supply areas. In some regions, county grids, or even inter-regional local grids, have been established. The size of local grids is

[4] 2002 represents the latest official source of statistics for rural electrification.

usually between 20 and 50 MW, and many are connected to larger grids. In principle, three fundamental electricity supply modes co-exist in rural areas.

(1) *Electricity supply by local grids*. In regions of abundant small hydropower, integrated generation, supply, and utilization systems are formed (in cooperation with small thermal power plants), with the county water resource bureaus or county small hydropower companies responsible for supplying electricity to rural areas. Dispatch and distribution voltage is usually 35 / 10 / 0.4kV. Local grids and state grids can be linked at a certain point to fully utilize the seasonal electricity generation and adjust electricity supply in high and low seasons.

(2) *Electricity supply by large state grids*. About two-thirds of counties rely on electricity supply from large state grids distributed through branches of the state grid company. In 2002, electricity from state grids accounted for 79.34% of total rural electricity consumption. From 1979-1998, there was a nationwide electricity shortage because demand for electricity outpaced supply. Shortages surfaced mainly in coastal areas where industrial demand grew fast. Rural access to electricity along the coast is almost 100%, but rural electricity is the first to be shut off whenever there is a shortage of power, as state industry and urban residents take priority in guarantying electricity. Electricity production in coastal areas is also highly dependent on coal from interior China and power transmission from inland hydropower and coal-fired power. This dependency has made it more difficult for the region to rapidly expand its own sources of supply. By comparison, in the central, western and northeastern part of China, shortages are less severe but electricity consumption is typically low. Due to high line losses and price-setting mechanisms of the electricity market, electricity prices for end users in the interior regions have historically been high. Thus, in some regions, even where electricity from large grids is available, users have been unable to afford electric power.

(3) *Electricity supply by a combination of local generation and large grids*. In regions of insufficient small hydro and thermal power, electric power is supplied through

a combination of local generation and wholesale electricity purchases from large grids. In China, these counties are referred to as "wholesale distribution counties" despite the presence of some local generation. In more developed regions, large grids are more competitive than both small grids and distributed suppliers, whereas the opposite is true in more remote areas where the cost of transmission is high and demand is low. Following management reform and system upgrading in 2003, however, large grids became the dominant supplier of electricity to rural areas. Local governments have their own electricity agencies and were the distributors of electricity until 1998 when they became part of the provincial grid companies.

2.3 Rapid increase in electricity consumption

Total electricity consumption at county and below levels in 2002 was 721.2 billion kWh, compared with 378 billion kWh in 1995. The rate of increase in these areas has been 9.7% per annum, compared with 7% for all China during the same period. In terms of per capita consumption, the rate of increase for China as a whole was 7.37% per year from 1980 to 2004, while for rural China the figure was 11.24% on average.

The structure of electricity consumption in rural areas remained largely the same throughout the 1990s. The share of electricity consumption by county towns and the rest of rural areas was 52% and 48%, respectively, in 1993 and this figure has remained unchanged into the 21st century. In 1993 the percentage share of county-level electricity consumption by industrial, agricultural and household sectors was 59.1%, 23.5% and 17.4%, respectively. Ten years later, those shares had changed only slightly, to 64.5%, 17.3% and 18.2% (see table 2).[5]

[5] China Power Yearbook, 1993-2003.

Table 2 Electricity consumption and uses at the county level and below

	Total county-level electricity consumption			By rural region				By end use sector					
	Bil kWh	over previous year %	over national total %	rural		County town		Industrial/service		Agricultural		households	
				Bil kWh	%	Bil kWh	%	Bil kWh	%	Bil kWh	%	Bil kWh	%
1993	294.0	12	35	151.8	51.6	142.2	48.4	173.8	59.1	69.0	23.5	51.3	17.4
1997	435.9	6.63	40.2	228.6	52.4	207.3	47.6	253.8	58.2	96.9	22.2	85.2	19.6
2000	566.9	13.79	42.75	292.1	51.5	274.8	48.5	347.0	61.2	105.7	18.6	114	20.2
2002	721.2	15.24	44.06	366.3	50.8	354.9	49.2	465.1	64.5	124.7	17.3	131.	18.2

Source: China yearbook of electricity industry, 1993-2003.

2.4 Sources of electricity supply

Rural electricity is supplied by two sources: large power grids and local generators. Total installed capacity of generating units at county and below levels in 2002 was 51.68 GW and electricity generation was 186.2 billion kWh, accounting for 20.66% of the electricity consumption.[6] Electricity supply from large grids was 572.2 billion kWh, accounting for 79.34% of the total consumption at county and below levels. Although local generation covers large geographical areas, its share of the national total is small and decreasing. In the early 1990s, local generation accounted for about 25% of the national total. Today it has decreased to less than 20%.

At the national level, over 80% of electricity has come from coal over the past two decades, with hydropower accounting for between 15% and 18%. Yet for local generation in rural areas, small hydro has been dominant, accounting for half or more of total electric power production (see figure 1). Small thermal power is also important, accounting for around 40% of local generation in rural areas. Small thermal power plants

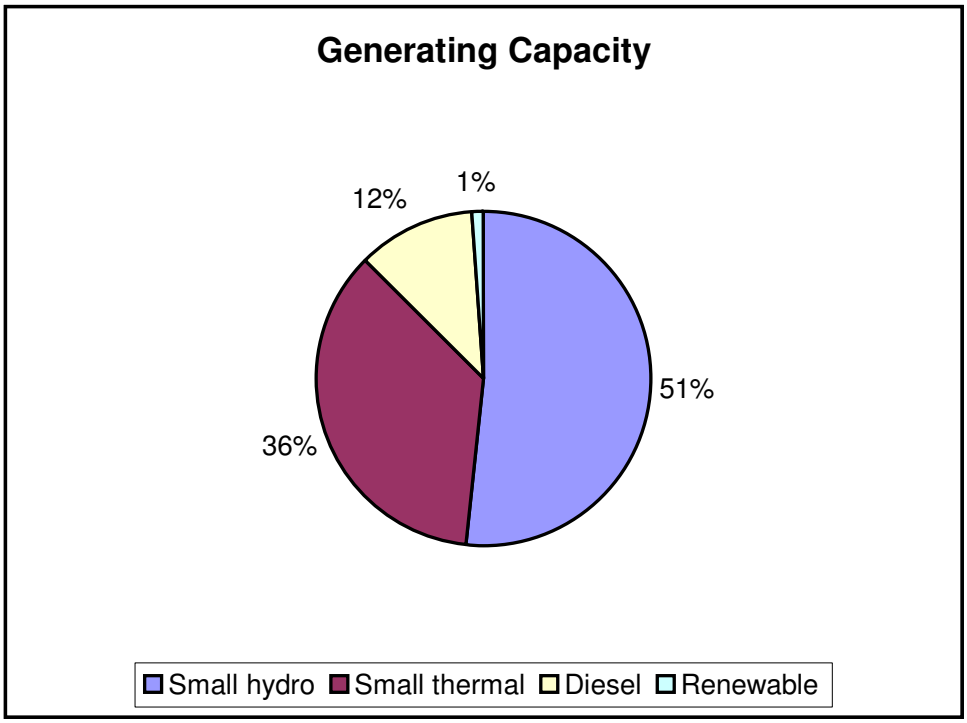
[6] These plants can be stand-alone or connected to a local or larger centralized grid. However, all of them can be considered to be local generation.

were typically built in small hydropower grid networks in order to improve the reliability of supply. National policies largely restrict small thermal power, but in rural regions where hydropower is not available or where coal is abundant, small thermal power is normally the solution to ensure stable supply. In 2000 twenty counties used small thermal plants as their primary electricity supply (compared with 433 that used small hydropower).

Another reason for the large share of small thermal is the use of combined heat and power. At the end of 2005, the research team made a field visit to Pinghu County in coastal Zhejiang Province. Out of a total electricity consumption 1.58 billion kWh from January to November 2005, 1.38 billion kWh came from provincial grids, with the rest from local small combined heat and power (CHP) plants and diesel generators (see Box 1).

Box 1 Combined Heat & Power (CHP) as a source of electricity production in the coastal regions: the case of Jingxin CHP Plant in Pinghu City

As enterprises in Pinghu county operate an average of four days per week with electricity from the power grid, they tend to rely on diesel generators if the scale of production is small, and on power from CHP if production is larger in scale. Jingxin CHP plant in Pinghu produces 650,000 tons of heat steam a year and 550,000kWh of electricity. There are four generating units of 6000kW capacity each. 70% of the electricity generated is sold to the provincial grid, with 12-15% for self use; the remaining share supplies some fifty enterprises nearby. Due to shortages of electricity from hydropower and large amount of private enterprise in the coastal region, diesel accounted for between five and ten percent of total power in 2002, although its share has been declining. Renewable electricity sources, excluding hydropower, such as wind, solar and geothermal, account for less than 0.5% of total power production.[1]



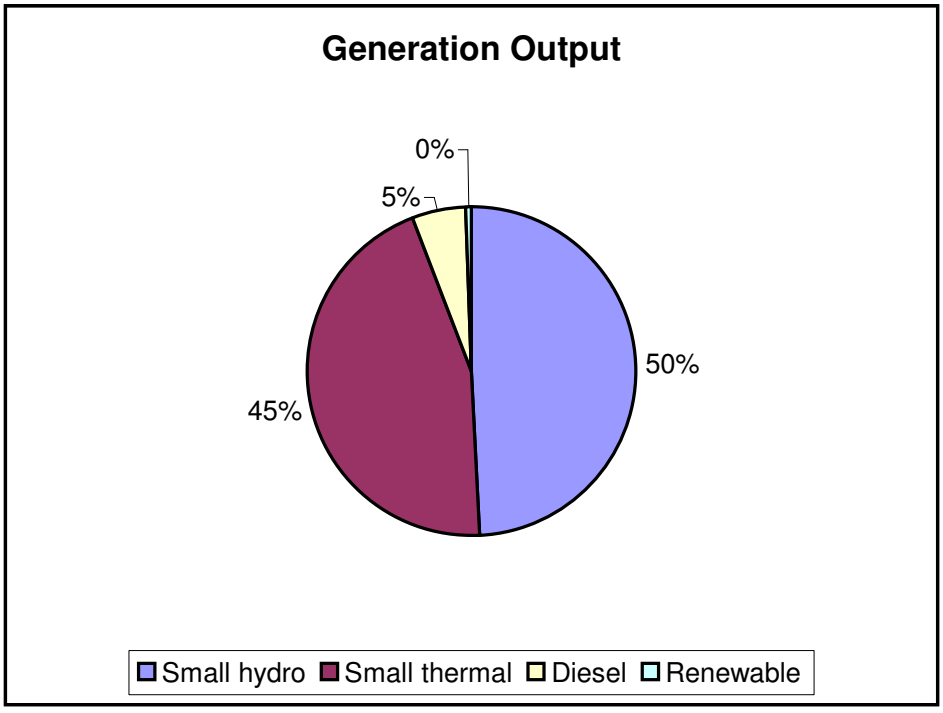


Figure 1 Sources of county-level and below electricity supply in 2002 by generating technology

(a) total capacity (51680 MW) and (b) total generation (186.2 TWh).
Source: China Yearbook of Electricity Industry, 2003.

III. The Historical Process

The process of rural electrification has seen a shift in priorities over time. Rural electrification as an independent (electricity) sector officially came to an end after 2003. This was signified by the dissolution of rural electrification departments within power companies, the State Power Grid Corporation and local electricity bureaus. Official functions for the promotion of rural electrification by the Ministry of Agriculture and Ministry of Water Resources have been greatly reduced and the rural electricity market has become dominated by the power companies. This section provides an overview of the process, focusing on the institutional and policy issues relevant to rural electrification.

3.1 Slow but steady development (1949-1978)

Electricity supply to rural China dates back to 1923 in Jiangsu Province, where coal-fired power was extended to neighboring rural areas for irrigation and food processing.[7] Later, small hydropower stations were constructed and became the central feature of rural electrification in China. In 1949, the year in which the People's Republic of China was founded, there were only 33 small hydropower stations in rural China with a total installed capacity of 3.63 MW; per capita capacity averaged less than 1 W. Total electricity consumption in rural China was 20 million kWh (Zhang Chao, 2005).

From 1949 until the late 1970s, China was under strict central planning and the country was largely isolated from the rest of the world. Industrialization took priority over agricultural development, while at the same time, addressing food shortages was a top government priority. Although rural electrification was slow, small in scale and employed backward technologies, steady progress was made.

[7] RED (2004).

3.1.1 Small Hydropower development in the 1950s

After the completion of rural land reform in the early 1950s, flood control projects and water conservation projects for farmland irrigation were built throughout the country to boost agricultural development and secure food supply. In order to make full use of hydropower, the central government required that small hydropower generating units be installed wherever possible. An administrative agency of Small Hydropower was established in 1953 under the Ministry of Agriculture and training was organized to provide experts around the county. In 1958, the strategy for preliminary rural electrification was specified as "small in size, commune-run, service mainly to the non-household sector, based mainly on hydropower and with an emphasis on both construction and management."[8,9]

There were many investments in water projects for farmland irrigation and flood control for improvement of food production. Capital was provided primarily by local government and farmers, with limited contributions from the central government. Labor was supplied by the local community and ownership rested with the local government.[10] By making use of dams and irrigation canals, small hydropower generation developed rapidly. By the end of 1959, 1000 small hydropower projects had been built, with an aggregate installed capacity of 150 MW. In 1959, rural electricity consumption reached 307 million kWh, but still only accounted for 0.6% of the nation's total electricity consumption (Li, 2004).

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[8] After the mid-1950s, the rural commune emerged as the dominant form for rural administration. While communes were collective organizations, the government took strict planning control and peasants worked for the commune. The rural commune system was abandoned in 1978 when rural townships were established as the grass-roots governmental administration.

[9] In 1958, a national meeting for rural hydropower development was held and it was decided to develop rural hydropower quickly in the second five-year plan (1961-65) to accommodate increasing rural electricity demand. At the meeting preliminary rural electrification was proposed in five counties and 100 communes. See Li (1999).

[10] This division of inputs and ownership structure was common to most public goods projects in rural China during the time.

During this period hydropower stations were operated on a single-station basis. Electricity from hydropower was transmitted at low voltage to local communities, mainly for lighting purposes. Large grids supplied mainly suburbs and the outskirts of large cities, and electricity was sent to rural areas via 6-10 kV distribution lines (Zhang Chao, 2005).

3.1.2 Extension of power grids and enhanced hydropower in the 1960s

The Great Leap Forward in the late 1950s ruined the Chinese economy. Starvation was widespread and industrial development slowed. In 1960 the government adopted a national economic development strategy of "taking agriculture as the foundation and industry as the leading sector."[11] The government decided to establish thirty-two agricultural bases for grain and cotton production. Rural electrification policy was adjusted to accommodate the need for stable agricultural production by providing electricity from large power grids for irrigation and drainage with supplementary supply of rural hydropower (RED, 2004). Immediately, electricity supply from state grids to rural areas began to expand.

To mobilize resources, the central government adopted an equal share arrangement for investments by the central government, county government and commune /village.[12] Investment from the central and county governments was in the form of capital for equipment and technology, while investment by the rural commune/village was in the form of labor. The dividends received by the central and local government were earmarked for a fund that sought to advance further hydropower development. This arrangement was the origin of the national policy of "revenue from electricity for

[11] To reconstruct the post-war economy and catch up to developed countries, China adopted the strategy of the Soviets. In the 8th plenary session in 1960, the country adopted a strategy that set artificially low agricultural prices and laid agriculture as the foundation of the economy, with industry at the core. (CPC, 1960).

[12] In China's administrative hierarchy, township is the lowest level of people's government. Provincial, county and township level governments are all referred as local in comparison to central. The village level is a self-organized collective with no government officials.

development of electricity" and the prototype of share-holding development of rural electrification (RED, 2003, Bai Lin, 2004). By this time, electricity from small hydropower projects was used not only for lighting and agricultural processing, but also for drainage, irrigation and industrial operations.

During the 2nd five-year plan (1961-65), the central government allocated 200 million RMB to improve safety and enlarge the capacity of rural electricity grids. This represented the first large-scale grid project in the history of rural China. Large national grids expanded to more city outskirts and some rural areas, and to some extent they replaced small hydropower projects (Li Qidao, 2003).

Despite the expansion of large grids, the installed capacity of small hydropower saw a significant increase, from 250 MW in 1960 to 255 MW in 1963, 380 MW in 1966, and 729 MW in 1969 (19,000 projects). During the 1960s, rural electricity's share of national electricity consumption increased from 1.36% to 10.9%; total rural electricity consumption reached 8.629 billion kWh.

3.1.3 Further expansion under the planned economy in the 1970s

In the 1970s rural small hydropower was further encouraged and a clear definition of small hydropower was given to guide the development process: less than 6 MW generating capacity per unit and less than 12 MW of total installed capacity (Zhang Chao, 2005). Resources were mobilized at various levels: prefecture, county and commune.[13] Ownership was determined by the principle of "the one who invests owns and operates the project."[14] The bulk of investment came from local government, but the central government provided some subsidies. To properly regulate relations between large and small grids, grid connection measures were agreed upon. After grid connection, the ownership of small power stations was to remain unchanged.

[13] At the village level, input was normally in the form of labor and mobilized at commune level.

[14] This policy was established by the former Ministry of Water and Power in 1973 and reiterated in 1975.

The establishment of these policies further attracted farmers, water agencies, and local governments to invest both money and labor in small hydro projects. The increase in installed capacity of small rural hydropower jumped from an average of 400 MW per year in the early 1970s to more than 800 MW per year in late 1970s. By the end of 1979, the length of high voltage electricity distribution lines in rural China had reached 1.02 million km.

Rural electricity consumption experienced a dramatic increase, and in 1978 the total electricity consumption at county and below levels was 51.023 billion kWh; per capita annual electricity consumption reached 64.6kWh.[15] The rate of access to electricity in rural areas increased considerably, with township, village, and household rates at 86.86%, 61.05%, and 53.3%, respectively. In 1979, rural electricity consumption totaled 59.28 billion kWh and the electricity consumption structure also changed considerably. County and township industrial electricity consumption rose to 33.2 billion kWh, accounting for 56% of the rural electricity consumption, compared with the dominance earlier of electricity for drainage and irrigation.[16]

3.1.4 Summary of stage I

During the three decades from 1949 to 1978 the primary driver for rural electrification—and in particular small hydropower development—was the improvement of agricultural production facilities, in particular irrigation and drainage to secure stable agricultural production. However, rural industrial development emerged toward the end of this period as the largest consumer of electricity in rural areas. During this period, more than half the Chinese counties developed hydropower facilities and for a long time

[15] "County level" often refers to the town in which the county government is located and the enterprises under the direct administration of the county. That is, rural township and village enterprises (TVEs) are excluded from county level statistics. "Below county levels" includes all the other townships excluding county level entities—for example, all TVEs, rural villages and towns.

[16] Data source: China yearbook of electricity industry (1980).

relied on rural hydropower stations for electricity supply. In aggregate, almost 500 million rural people were given electricity access.

3.2 Rapid expansion and large scale development (1979-1998)

At the end of 1970s, with the end of the Cultural Revolution and the introduction of economic reform, TVEs and rural household contract production were the two dominant features of rural development in China.[17] The expansion and increase of electricity consumption in rural areas led to incessant rural grid expansion and the grid framework mainly of 110 kV (with some 63 kV) lines started to take shape.

3.2.1 Preliminary electrification of rural counties through hydropower

In 1983 the State Council issued No. 190 Document demanding that in areas with favorable water resources local government and non-governmental entities actively develop rural hydropower. This was accomplished through a combination of political incentives (promotions) for local officials and financial incentives (matching funds and favorable tax policies). To further advance large scale rural electrification, 100 pilot counties were selected for preliminary electrification (Jiang Fuhua and Du Xiaozhong, 2004).

The government's goal was to accomplish electrification in the first set of pilot counties during the 7th five-year plan (1986-1990). At the end of 1990, 109 counties met the requirements for rural hydropower preliminary electrification.[18] This large-scale rural

[17] The landmark is the holding of the 3rd Session of the 11th Conference of the Chinese communist Party in March 1978, at which Deng Xiaoping took full control of power. The rural household contract production system allowed households to keep their surplus after selling their contracted production quotas to the state government.

[18] Requirements included that 90% of the rural households have access to electricity for lighting, broadcasting, TV round the year and cooking seasonally, and for irrigation, food processing and TVEs. On average, per capita electricity consumption is around 200 kwh and generation capacity at 100W/capita. Details are given in GB (National Standards)/T 15659 – 1955. See also, Zhou and Wang, (2003), Zhang Chao (2005).

electrification scheme continued until the turn of the century. In just over sixteen years, the government managed to electrify 653 counties in remote rural areas mainly through hydropower development. Nevertheless, the criterion for preliminary electrification was set low, at 200 kWh per capita, close to the level of basic consumption needs (1 kWh per family per day, as evaluated by EDF, 2002).

In the course of rural preliminary electrification, the government offered a series of policies supporting the development of rural small hydropower including: (1) the strategy of "the one who invests owns and operates" and the principle of "unified construction and operation for unified generation and supply"; (2) a subsidy for rural hydropower electrification with RMB 100 million, 200 million, and 300 million per year from the central government for the 7th, 8th and 9th five year periods, respectively; (3) special loans for rural hydropower; (4) the policy of "revenue from electricity for development of electricity"; (5) a preferential rate of value added tax rate of 6% instead of the normal 17%; and (6) the connection of small local grids to larger grids.[19]

Despite the significant subsidies provided during this time period by the central government, other sources of funds outweighed direct central investment in small hydropower by the end of this period. Among the funds for small hydropower development in 1996, only 12% came from central government; 45% came from bank loans, 29% from local governments, 6% from direct foreign investment, and 8% from other sources.[20]

[19] State Council Documents No.190 [1983], No.17 [1991] and No.2 [1996]. These documents created a policy of promoting medium and small hydropower for rural electrification development and the specific incentives and programs to accomplish those goals. The policies were successful in creating a rapid growth in small hydropower and reduction in the number of unelectrified households. See Jiang Fuhua and Du Xiaozhong, 2004.

[20] China Power Yearbook, 1993-2003. The interest rate of the bank loan was very low and mainly through China Agricultural Bank or Co-operative Bank of China. And it was implemented according to central government policy.

3.2.2 Institutional strengthening and financial incentives

In 1982 the former Ministry of Water and Power set up a Rural Electricity Department and local agencies followed suit to create similar divisions. In 1992 rural electricity supply from the state grid was transferred to the Ministry of Electricity (now the State Power Grid Company). However, within the Ministry of Water the Rural Energy and Rural Electrification Department was established to assume responsibility for rural electrification. Now there are five levels of electricity administrative agencies: national (State Power Corporation and the Ministry of Water), provincial (provincial power companies and water departments), prefectural/city level (electricity bureaus, water and electricity bureaus), county level (electricity bureaus, water resource and electricity bureaus), and township electricity administrative stations. Under this hierarchical institutional structure, rural electrification received support from various levels of governments, but was under strict control at every level.

During the 8th and 9th Plan Periods (1991-1995 and 1996-2000) the financial resources available were, respectively, RMB 200 million and RMB 300 million/year grants from the central government. By the end of 1997 the accumulated fund for rural electrification totaled RMB 9.95 billion (including sources from central and local governments, bank loans and private investment). Investment in 20 counties exceeded RMB 100 million per county.

In May 1994 the State Development Planning Commission, the State Economic and Trade Commission, and the Ministry of Electricity Industry jointly initiated the "electricity for poverty alleviation project." In 1994 a total of RMB 720 million was spent on alleviating poverty by increasing electricity access; by 1996 RMB 2.1 billion had been invested in the program (Li Qidao, 2003).

3.2.3 Summary of stage II

By 1998 China's total rural (county and below level) electricity consumption was 495.5 billion kWh, accounting for 40.53% of the national total. Total installed capacity of

generating units at county and below levels was 44.15 GW and total electricity generation was 132.1 billion kWh, accounting for 26.7% of total electricity consumption at county and below levels; the remaining 73.3% came from large grid supply. Electricity access rate for rural townships, villages, and households was 99.2%, 98.1%, and 96.87%, respectively. Township electricity access rate was 100% in 2231 counties (out of a total of approximately 2300 counties). 100% village-level access was realized in 1831 counties. In 1787 counties 100% of rural households had been provided access to electricity. In only fifty counties was the household access rate lower than 50%. By the end of this stage, eight counties, 364 townships, 14,042 villages, and 8.81 million rural households lacked access to electricity.[21]

3.3 Reform, Consolidation and Upgrading (1999-2004)

The barriers to creating an efficient, profitable and well-run rural electricity system—including institutional, physical and technical—have long been identified, but it was not until 1998 that the government decided to tackle them. Due in part to the Asian financial crisis when foreign direct investment was reduced and exports decreased, there existed excess electricity supply due to decreased industrial demand and the shutdown of inefficient, energy-intensive state enterprises. At the same time there existed the potential to increase electricity supply to rural China, a region still suffering from a shortage of supply. However this potential was not easily realized due to deterioration of the rural electricity system and high tariffs in rural areas. The rate of increase in electricity consumption from 1990 to 1996 was 9.68% annually but it then decreased 4.65% between 1996 and 1999. From 1999 to 2004, electricity consumption rose again by an average of 12.03% per year (NSB, 2005).

In 1997 the government identified the following major problems with rural electricity supply: (1) rural grid equipment was outdated, impeding safe and reliable

[21] China Power Yearbook (1999).

electricity supply; (2) rural grids were not well planned and constructed, with such problems as irrational layout, excessively long electricity supply radius, poor supply quality, low reliability, high wire losses, inefficient distribution of electricity, and lack of supply; (3) the management system was fragmented and there existed conflicts of interest among the players in the management of rural electricity supply systems; and (4) low quality of grids led to high wire losses and excessively high electricity tariffs for end users, which depressed the development of the electricity market in rural areas.[22]

During the second half of 1998 China began to implement a rural grid renovation program in order to stimulate rural economic development, boost consumption and decrease disparities between rural and urban residents. The target of the program was to create a unified electricity tariff for urban and rural users within the same grid. Two initiatives were advanced to achieve the target: reforming rural electricity management systems and renovating rural grids.

3.3.1 Rural electricity management reform

The government's strict control of the utility sector in rural areas was administered through the local government in the case of small hydro plants. However, the resulting service was often poor due to the conflicting priorities and incentives of local governments in management and operation of local utilities. There was little distinction made between the local government and the local utility and the utility was considered a revenue stream for the local government instead of a commercial entity. Revenue transfers from the utility to the local government reduced resources available for proper operation and upgrading of the electricity system. The central government decided to reform the rural utility sector by creating electricity entities in the form of commercial companies rather than government-affiliated subordinates at the state, provincial

[22] In 1997 the Ministry of Water identified the existing problems and gave reform directions for rural electricity supply in No.95 document.

(electricity companies), and county (electricity supply enterprises) levels. Electricity administrative agencies and electricity supply enterprises at the county level were to be separated, and the county economic and trade commissions were to take over the administrative functions. Where there existed multiple electricity supply enterprises, limited liability companies or share-holding companies were to be established according to capital contributions so that there was only one electricity company in a county and county and township electricity management was integrated.[23]

Direct supply and management counties were gradually turned into wholly owned subsidiaries of respective provincial electricity companies. In principle, electricity supply enterprises in wholesale counties were put under the direct management of provincial electricity companies. If the upward transfer was not carried out, provincial electricity companies were either entrusted to play the management role or these enterprises were gradually turned into limited liability or share-holding companies through equity shares and other approaches. Electricity supply enterprises in self-supply and management counties implement the reform process according to the requirement for liberalization of the electricity market so as to reduce government intervention.[24] The government reform package encouraged independent small power grids to be part of larger companies.

[23]After nine months of communication and consultation at central level, the General Office of the State Council circulated its 134th decree on October 4, 1998, officially initiating the reform, renovation and unified pricing program. In 1999, the State Council No. 2 document stipulated the details for rural power system reform, including the principles, targets, contents and organization measures and requested that the reform be completed in about three years. See Li Qidao (2003) for details.

[24] The direction of national electricity industry reform is "separation between government administration and enterprise operation, electricity generating plants and grids, transmission and dispatch, and major operations and secondary operations," in order to break monopoly and introduce competition. See Li Qidao, 2003.

3.3.2 Rural grid renovation

Through renovation, rural grids were expected to achieve high reliability as a result of rational layout, advanced equipment, scientific management, sound communication, and high levels of automation (Li Qidao, 2003).

In 1998 the Chinese government invested RMB 290 billion to renovate rural grids within five years. In principle, the provincial electricity companies acted as project owners during grid renovation and took on the responsibility of unified planning, construction, management and operation. The principal repayment and interest payment of the rural grid renovation cost were included in grid costs and amortized into the national electricity tariff. After renovation, overall wire losses of high voltage grids were lowered from 12% to less than 10% and wire losses of rural low voltage grids from 20% to less than 12%.

In the 21st century, the rural electrification program has further developed. The 10th five year plan (2001-2005) was approved by the State Council in October 2001 and includes funding for an additional 400 counties to meet the official criteria to be considered "electrified."[25] Total investment was estimated at over 50 billion RMB, covering 24 provinces and 200 million people (Statistical Bulletin, 2002). By the end of 2003 over RMB 35 billion had been injected into rural electrification and the total additional installed capacity of small hydropower exceeded 4 GW.

[25] See Footnote 18 for the definition of a rural electrified county.

Table 3 Major features and stages of rural electrification in China

Stage	Period	Key features	Access to Electricity		Macro- and strategic orientation	Primary Policies
			million	%		
I	1949~ 1978	Slow but steady development	500	63.28	Agricultural production, resource (hydropower) use; strategic investment in inland areas; rural industrial development	Strong central planning, state investment and control, Shared ownership; revenue from electricity for rural electricity, subsidy and tax relief, grid connections
II	1979~ 1998	Rapid expansion and large scale development	823	98.94	Rural industrial development, regional development, social and environmental considerations; Control relaxation; grid expansion; pilot counties for electrification; financial aid	Central government investment, Local government initiatives, private sector investment, special loans; grid connection, financial incentives
III	1999~ 2004	consolidation and Upgrading	776	99.21	Institutional reform, Boosting electricity demand, integration of rural and non-rural electricity market, fuel substitution for environmental protection, quality of rural life	Rural electricity management reform; grid renovation; unified electricity price within one grid; government administration and enterprise operation split, separation of power plants and grids, dissolution of government electricity bureaus

Source: China Statistical Yearbook, China yearbook of electricity industry, various years. Access is in general is a rough estimate. In particular in the process of urbanization, rural population figures are in general on the decline but the exact numbers can differ. See explanatory notes on statistics.

3.3.3 Summary of stage III

By implementing a unified tariff for both urban and rural consumers, management reform and rural grid renovation, the government was able to consolidate and upgrade the rural electricity system. This program also electrified six counties and extended electricity to 25 million people. Electricity access rate, consumption, and supply quality all saw major improvements. The amount of time that voltage was in its desired range generally reached more than 90%, 12% higher than before the renovation. The reliability rate of electricity supply (based on outage times) reached over 95%, 8% higher than before the renovation; in some regions, reliability reached 99%. Grid losses declined by

25%-30%, to about 12%. In rural areas, the average end-user electricity tariff was reduced over RMB 0.13/kWh. As a result, each year rural households save a total of approximately RMB 42 billion in electricity costs.

3.4 Overall Summary

Remarkable rural electrification achievements were realized in China over the past fifty years. The installed capacity of electricity generating units (at the county-level and below) increased from 3.6 MW in 1950 to 51,680 MW in 2002. The average annual growth rate was 20.19%. Electricity consumption at county and below levels leapt from 0.02 billion kWh in 1950 to 721.2 billion kWh in 2002, with an average increase of 22.36% per year (see Table 4).

The rate of access to electricity increased from virtually zero in the late 1940s to 86.9% (rural townships), 61.1% (villages) and 53.3% (households) by the late 1970s. It further increased to over 98.5% of rural townships in 2002 (Li Qidao, 2004).[26]

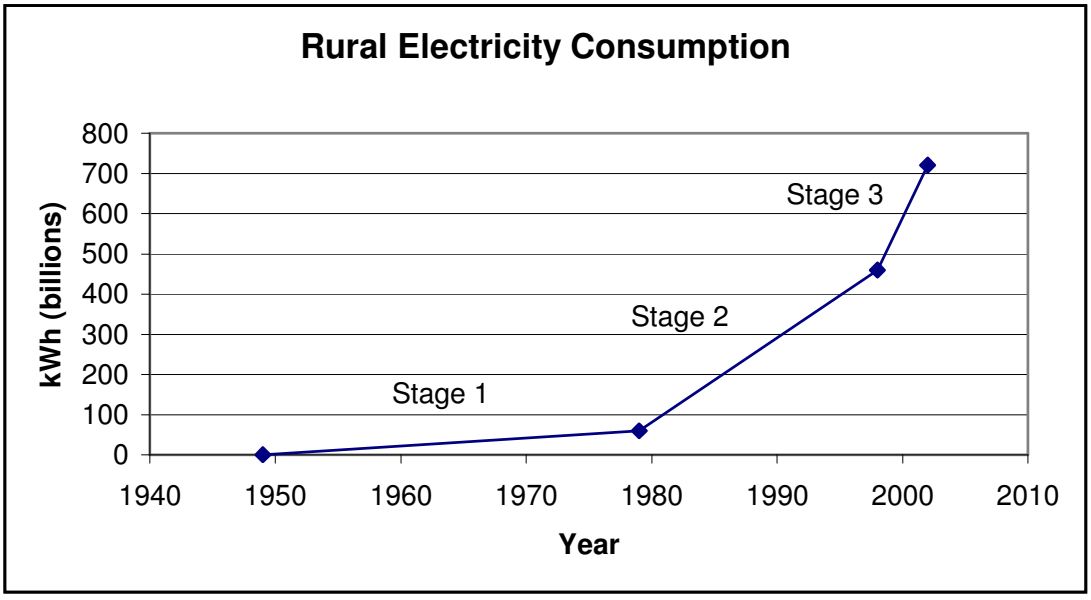

Figure 2 Electrification development at the county level and below (1949-2002)

[27.] China Power Yearbook, 1993-2003.

Figure 2 indicates the increases in electricity consumption during each stage. Major features and stages of rural electrification in China are summarized in table 3. While access has neared its limits, there is much further to go in terms of increasing consumption levels. Before the reform and renovation, there were two markets for electricity: rural and non-rural. With the integration of rural electricity management and market into a commercially-based regional market, deepening rural electrification will depend on the functioning of the market. The government will no longer be the sole owner and operator of rural electricity systems.

IV. Key Drivers of Rural Electrification in China

Table 4 Rural Electrification Development at County and Below Levels

Year	Installed capacity at end of year (MW)	Average annual growth rate	Electricity consumption in the year (bn kWh)	Average annual growth rate
1950	3.6	-	0.02	-
1979	6380	29.38%	59.28	31.74%
1998	44150	10.72%	495.50	11.82%
2002	51680	4.02%	721.20	9.84%
1950-2002		20.19%		22.36%

Source: calculated by the author from table 2.

4.1 Strategic industrialization policy

When communist China was established in 1949 industrialization and modernization of the country took priority. To support the development of heavy industrial sectors, the government followed the Soviet approach, squeezing all surpluses from the agricultural sector by artificially setting low prices of agricultural products and sparing few resources for rural development. Rural electrification was not high on the government agenda.

Nonetheless, spillovers of this strategic policy have played important roles in rural electrification. First, industrialization requires support from the agricultural sector,

particularly in the form of food and raw materials for industrial production. In the first stage of rural electrification, and to a lesser extent in later stages, government encouraged the supply of electricity to rural areas, not for household consumption but for improvement of irrigation and drainage for agricultural production. Second, regional infrastructure and strategic investment projects were constructed. Rural areas close to railways, roads, and mining fields were among the first places electrified. In the 1960s and 1970s the central government relocated industries of strategic importance to remote inland areas for reasons of national security. Third, the rise of rural township and village enterprises was consistent with China's goal of industrialization and urbanization. Power grids were extended, although rural areas were discriminated against whenever there was a shortage of power supply. Fourth, the government responded to the 1997 Asian financial crisis with the large-scale shutdown of state-owned, electricity-intensive enterprises. Growth in electricity consumption dropped dramatically (see figure 3) and the government saw the growing rural market as a potential consumer of the surplus electricity.

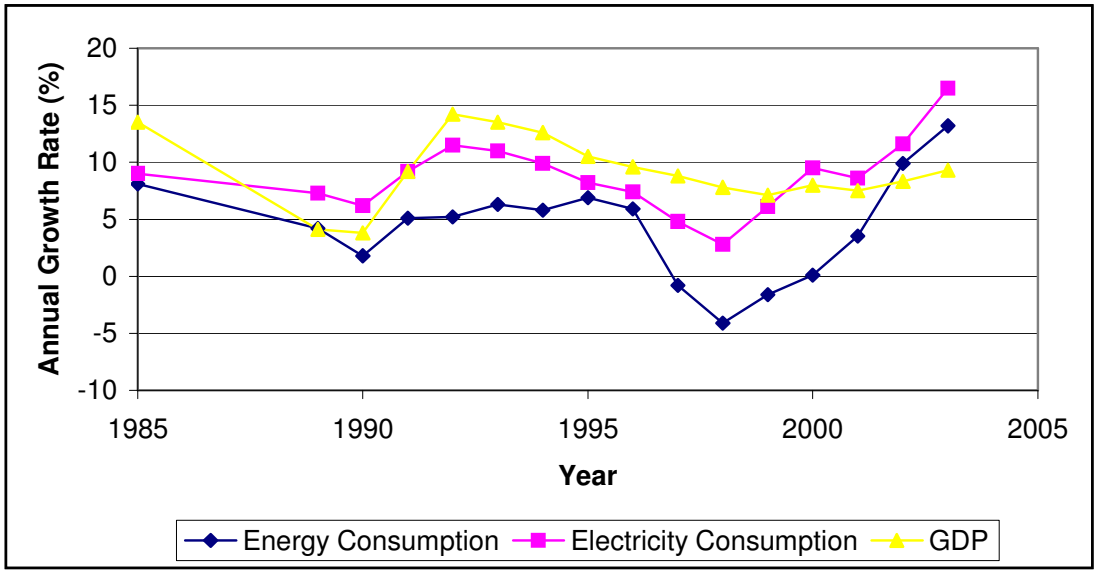

Figure 3: Annual growth rate of GDP, electricity and energy consumption, 1985-2003.

Source: China Statistical Yearbook, various years.

4.2 Rural social and economic development policy

A second category of top-down policy was targeted directly at rural electrification for social and economic development. China is diverse in both its geography and economic characteristics, and economic development has been unbalanced among regions. Gaps between rural and urban and between east and west are widening. The extension of large power grids to rural areas is expensive, but local hydropower resources are readily available in many locations.

In the 1950s and 1960s local governments attempted to develop small hydropower resources, but they were small in scale and highly isolated and scattered. Beginning in the early 1980s, the government launched a series of electrification programs in rural counties on a much larger scale, each aimed at hundreds of rural counties in inland and remote areas.[27] From 1986 to 2000, 653 rural counties achieved a basic level of electrification, covering 252 million people and 2.74 million km^2. [28] By the end of 2003, 48,000 small hydropower stations had been built in over 1600 counties, with a total installed capacity of 31.2 GW and an electricity output of 110 billion kWh. Over 800 county grids and 40 regional grids were constructed. In over 800 counties, the major source of electricity is hydropower, providing electricity access to over 500 million rural people (Zhang Chao, 2005). In addition to the small hydropower projects, the National Development and Reform Commission and local governments supported distributed generation systems powered by wind and PV (Qinghua, 2005).

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[27] It was formally decided to select the first set of 100 pilot counties for rural preliminary electrification; the second set was 200 counties, the third set was 300 counties.

[28] Requirements for basic electrification include 90% of the rural households have access to electricity for lighting, broadcasting, TV round the year and cooking seasonally, and for irrigation, food processing and TVEs. On average, per capita electricity consumption is around 200 kwh and generation capacity at 100W.c. Details are given in GB (National Standards)/T 15659 – 1955. See also, Zhou and Wang, (2003), Zhang Chao, (2005).

According to Liu Jinghe (2005) and Zhang Chao (2005), major social and economic benefits of rural electrification include[29]:

1) *Contribution to local employment and income generation.* The asset value of hydropower stations alone is over 200 billion RMB and sales value totals over 50 billion RMB a year. Construction, operation and maintenance of rural electricity facilities employ millions.
2) *Ecological and environmental protection.* In 2003, small hydropower was equivalent to 44.44 million tce. This would mean that over half a million tons of SO_2 emissions were avoided and nearly 100 million tons of bio-fuels (fuelwood and crop residues) were not cut and burned for fuel. In 2003 the government initiated the Program on Small Hydropower for ecological conservation (Liu Jinghe, 2005).[30] According to the plan, some 28.3 million rural households (104 million people) will use electricity from small hydro for cooking and heating by 2020. Total investment under this

[29] The Regulations and Procedures for Economic Evaluation on Small Hydropower Construction Projects issued by Ministry of Water Resources in 1995 (national industrial standards) provides a list of the social benefits from small hydropower, which include the following aspects: (1) Promoting the development of local and township industrial enterprises and GDP growth, and improve industrial structure of rural areas; (2) Boosting the development of farming, forestry, husbandry, by-product, and fishery and contributions to grain output and total output of the agricultural sector; (3)Promoting and improve water conservancy, flood control, and resistance to draughts; (4) Increasing national and local fiscal revenue, expanding accumulation, promoting local economy, and facilitating rural economic structure development toward commercial economy; (5) Changes in local per capita grain production and per capita income; (6) The influences of improving rural labor structure, increasing energy supply, expanding production, creating jobs, and stabilizing social order; (7) Boosting the production development and living standard of border and ethnic regions, contributing to national unity, and consolidate national defense etc. The cultural benefits mainly lie in the following 3 aspects: (1) Promoting broadcasting, TV, and electronic based education, spreading knowledge, and improving the people's cultural quality; (2) developing film, TV, and broadcasting, increasing cultural stadiums, libraries, and evening schools, improving people's cultural life, political awareness; (3) Contributing to the development of science and technology and expertise in rural areas.

[30] The Ministry of Water completed the national Plan of Small Hydropower as Rural Fuel for Ecological Conservation, which followed the decree on Agricultural and Rural Work by the Central Communist Party and the State Council in 2003. Zhang Chao (2005, p. 187-8) calculates that rural households would be able to pay for electricity for cooking and there is sufficient small hydropower for development in rural areas.

program is estimated at 127.3 billion RMB.

3) *Promotion of industrialization and urbanization.* Electricity allows township and village enterprises to be developed in the industrial and service sectors.
4) *Enhancement of agricultural production.* With electricity, irrigation and drainage, as well as food processing systems have been developed, allowing farmers to grow more crops. In the case of small hydropower, reservoirs are constructed not only to generate power but also to aid in flood control and water supply.
5) *Improvement in rural welfare.* Access to electricity has the potential to enhance rural education, healthcare, culture, and information dissemination. Substitution of electricity for biofuels for cooking and heating can eliminate indoor air pollution, reducing severe adverse health problems.

4.3 Favorable electrification policy environment

The Chinese government has implemented a series of policies to encourage local governments, communities, the private sector and households to explore locally available small hydropower resources in mountainous regions (Zhang Chao, 2005). The guidelines of "the one who invests manages and benefits on their own initiatives," issued in the early 1960s, significantly boosted the development of small hydropower. "Self-initiated investment" gives freedom to local governmental and non-governmental stakeholders to utilize local resources, technologies and raw materials to plan and construct local small hydropower stations. Investment is mainly from local sources, and in some cases small hydropower equipment is also produced locally. The management system of small hydropower can form a unified small hydropower market of integrated generation, supply and use. This policy can be regarded as a market-oriented operation under a planned economy.

This overall policy is supplemented and strengthened by a series of administrative and incentive arrangements.[31]

Leading responsibility by local chief administrative officer. In every county a rural electrification leading group, led by the county governor, was established to make key decisions in the construction, fund raising and other key elements of the rural electrification effort.

Establishment of the rural hydropower construction fund. In rural areas covered by hydropower supply, two cents/kWh are collected and the money is allocated to the rural hydropower construction fund. Some provinces increase the levy to four cents/kWh by issuing supplementary regulations.

The policy of "revenue from electricity for electricity purposes". Profits from small hydropower and local grids are not surrendered to local fiscal agencies, but are retained by enterprises for further small hydropower development. This policy has been implemented for nearly twenty years and has greatly boosted the development of small hydropower.

Taxation policies. Before the taxation reform of 1994, small hydropower only needed to pay product sales tax equivalent to 5% of the power stations' sales revenue. Since 1994, a 6% VAT tax is charged to rural electricity operators, versus the 17% VAT paid by large power stations and large grids. As for corporate income tax, the national level is 33% of taxable profits but all provinces have some of preferential regulations, such as "two years of exemption and three years of half payment" and "first collection then refunding."

Loan policies. China Agriculture Bank arranges for special accounts for rural hydropower loans. In some provinces, governments offer loans at subsidized interest rates.

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[31] Details can be found in State Council Decrees 1980 – No 190; 1991 – No 17 and 1996 – No 2. See also Jiang Fuhua and Du Xiaozhong, 2004.

Policies designed to protect electricity supply areas for small hydropower. The country stipulates that large state grids support small grids and, when conditions permit, large and small grids be connected for mutual supply and electricity supply adjustment. Large grids are prohibited from crowding out small ones, taking over their consumers, or acquiring small grids more generally. As discussed later, the policy of protecting small hydropower supply areas eventually came into conflict with other policies and resulted in many small grids being taken over by the large grid companies (with no compensation).

4.4 County-based decentralized management system

Rural electrification in China has been largely implemented using the county as a management unit. The suburbs of urban areas are the responsibility of the city government and have typically been covered by large power grids earlier than more rural regions.

Counties, as compared with prefectures and provinces, are a more manageable size and have the financial authority for local projects. While strategies, targets, standards, and policies for small hydropower development are established by the central government, other issues, including planning, development, operation, management, and equipment manufacturing, are carried out at the county level.

4.5 Demand pull

Access to electricity does not mean that electricity is used in rural areas. There must be demand for electric power.

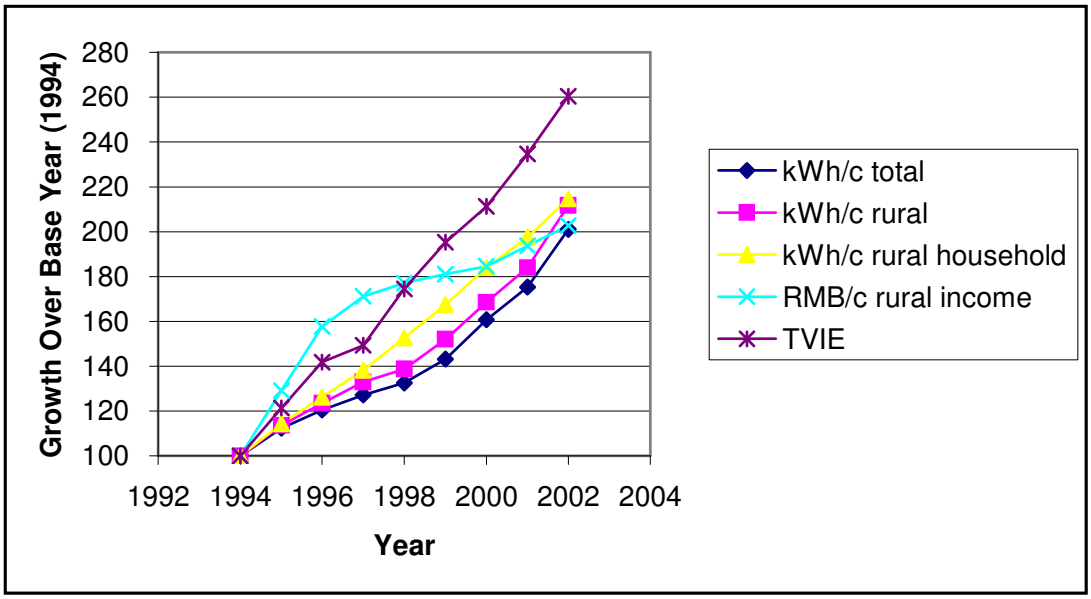

Figure 4 Growth in TVIE (Township and village industrial enterprises) output, rural household income and electricity consumption (total, rural total, and rural households), 1994-2002. (1994=100)

Note: Rural agricultural consumption per capita is not shown as it has remained steady over this time period. This accounts for the fact that rural household and TVIE growth was higher than total rural per capita electricity consumption growth.

Source: Zhang Yi and Zhang Songsong (2002, p. 276), Ministry of Agriculture (2004), National Statistic Bureau (various years), and China Yearbook of Electricity Industry (1994-2003).

Although early demand for electrification in rural areas was for improving agricultural production, the share of electricity consumption by the agricultural sector has been rather small and stable. The largest demand is from the industrial sector. However, this demand is not comparable to the development of township and village enterprises in driving up demand for electricity in rural areas. The growth in output of township and village industrial enterprises is much faster than the growth in consumption of electricity and the growth in rural household income (see figure 4). Growing from virtually negligible in the 1960s to about half of the total value added of industrial output at the national level by late 1990s, rural industrial uses of electricity accounted for over one-fourth of total national consumption of electricity and nearly two-thirds of electricity

consumed in rural areas. It is these large and stable consumers that can support quality service of rural electricity supply (Zhang Yi and Zhang Songsong, 2004).

The ultimate beneficiaries of rural electrification are households. The rate of access to electricity by rural households is now over 98%. Increases in income by rural households have resulted in high appliance ownership and electricity consumption. Per capita rural income has increased from a few hundred yuan per year in the early 1980s to over RMB 3000 per annum recently (compared with a national average of RMB 8000 per capita). Electric appliances are not uncommon in rural households; even highly expensive and electricity-intensive products, such as refrigerators and air conditioners, are becoming common. Since 2004 the central and provincial governments have begun to phase out taxes on agricultural crops, further enhancing the purchasing power of rural households.

4.6 Electricity market policy

Rural electrification in China is realized via two approaches: small hydropower and rural grids built by local parties ("point expansion"); and the expansion of large grids to rural areas ("radial expansion"). As these two forces expand, competition for electricity supply areas is inevitable. This leads to ups and downs in small hydropower development.

In the over 50 years since the foundation of the Republic, the state electricity industry has been experiencing continuous expansion in scale and has played an important role in supporting national economic development. During the 1950s state grids could not satisfy the electricity demand of cities and were unable to expand coverage to rural areas. Under the guidelines of "focusing on small hydropower projects funded by communes and mainly for production purposes," rural electricity experienced rapid development.[32] This was a period of mutual supplementation between state and local grids without common borders. In the late 1960s, due to the national policy of

[32] The strategy for preliminary rural electrification was put forward for the first time in the national rural hydropower meeting in 1958. See Li Qidao (2003) for details.

giving priority to large grid development, state grids began to expand to some rural areas and replace small hydropower stations. Some isolated small hydropower stations, lacking their own grids, were abandoned. Local investors realized that their small hydropower stations needed to have their own protected electricity supply areas. Under the coordination of the State Council, small hydropower stations not only obtained the policy of the "benefits should go to the investors and the operators," but also allowed grid connection and prices favorable to small hydropower producers. However, the ability of small hydropower producers to obtain favorable grid-connection rates has been varied. Some (such as in Zhejiang province, where power is in high demand in industrial areas) are able to negotiate favorable wholesale rates that cover their capital and operational costs. Others found their wholesale rates to the utility after grid connection to be significantly lower than what they used to be able to charge their retail customers.

In the 1970s rural small hydropower stations and small grids saw rapid development. The average annual installed capacity growth was more than 800 MW. But beginning in 1978 the expansion of large state grids to rural areas also sped up and small local hydropower and large state grids began to compete. Large grids started to strike and depress small hydropower and local grids through grid connection prices, electricity dispatch, and load control. With the program of "unifying electricity price in rural and urban area in a single grid, reforming rural electricity management system, and renovating rural grid facilities,"[33] competition between state grids and local grids reached their peak. State grids took the opportunity to take control of local grids. Local governments were unhappy with the measures and impeded the process. Competition between water agencies and state electricity companies for the administration of hydropower was also extremely fierce.[34]

[33] See No. 134 Document issued by the State Council in 1998.

[34] For a detailed review of the issues, see Li Qidao (2003).

As a byproduct of competition between local and state grids, rural electrification witnessed rapid development. For an extended period of time, China implemented a system whereby a large share of taxes from state enterprise went to central coffers, while a large share of taxes from local enterprises went to local purses; most county electricity enterprises served as pillars for the local economy. Competition for rural markets inevitably influenced actions of investors, particularly private investors.

Table 5 Technical features of small hydropower in retrospect

	Def. By size (MW)	Total inst. (MW)	Elect. Gen. billion kwh	Units and operation	Power transmission	Uses of electricity
1950s	<0.5	0.15	-	Iron & wooden turbine, single station	400V, local use	lighting
1960s	<3.0	0.73	-	Molded iron turbine, multiple station connected	10 kV	Lighting & food process.
1970s	<12.0	6.33	-	Series units, partial auto control	35 kV, county local grids	Lighting, food process. Irrig., county enterp.
1980-90s	<25.0	10.10	29	High efficiency units, automatic operation	110 kV, local grids	County level electrification
2003	<50.0	31.20	110	High efficiency units, automatic operation	110 kV, connected local grids	Regional electrification.

Source: Liu Jinghe, 2005, Zhang Chao, 2005, pp. 183-5.

4.7 Technological progress

For remote rural areas, access to electricity is highly dependent on the development of technologies. Through R&D, the cost of electricity generation, transmission and

distribution declines over time. Table 5 gives the definition of "small hydropower" with a set of indicators that are highly related to technologies. The Ministry of Water issued a directive in 2003 demanding the modernization of rural hydropower technologies.[35] The overall objective was to have 50% of hydropower plants and related facilities modernized by 2010 and full scale modernization of the small hydropower sector by 2015.

In remote rural areas without hydropower, and far away from diesel distribution channels, the only commercially available sources of electricity are wind and solar PV, which are very expensive and technologically complicated. Nevertheless, technological progress has made some wind and solar power competitive in the rural electricity market. In 2002, NDRC started a program to electrify rural townships, where rural government is located, in seven western provinces, investing 2 billion RMB in solar PV that will total up to 20 MW.

4.8 Program of fuel substitution by small hydropower

In 2002 and 2003, the Communist Party of China (CPC) Central Committee issued two directives, requesting that efforts be made to provide energy to rural households in ecologically fragile regions where arable land was reforested. In response to the CPC requests, the Ministry of Water completed a comprehensive plan to develop small hydropower as a substitute for biofuels.[36] This substitution program is to be implemented in 25 provinces (autonomous regions and municipalities) containing 886 counties, 70.8 million farmer households, and 273 million people. Between 2004 and 2020, 24.04 GW of small hydropower capacity will be constructed, providing electricity for cooking to 28.30 million of these rural households. This will replace firewood for cooking and

[35] For technical details, see Zhang Chao, 2005, (pp. 193-199).

[36] The Ministry of Water is the national agency implementing the program on fuel substitution by small hydropower. See Bai Lin, 2004.

heating during the six to seven months of the rainy season.[37] Each year, fuelwood cutting will be reduced by 149 million m^3 and the annual consumption of electricity per household used to substitute for bio-fuels will reach 1200 kWh on average. During periods of low water or drought, straw and biogas can be used as fuel for cooking or electricity from other sources can be purchased to supplement supply.

The program of fuel substitution with small hydropower will involve power station and grid construction and other associated facilities. Investment is needed from central government subsidies and loans from China Agriculture Bank. The household electricity tariff for electricity generation by small hydropower is around RMB 0.17/kWh (slightly lower than the RMB 0.20/kWh average long-run cost of electricity production) in order to make electricity cooking desirable and affordable to farmers (Li Qidao, 2003, Zhang Chao, 2005).

4.9 Multiple investment sources

Since the rural electricity reform of the late 1990s, various market players have been encouraged to participate in rural electricity construction via shareholding and other forms of cooperative investment; the share of private enterprises in hydropower has gradually increased. For example, during the 9th Five-year Plan (1996-2000), Guangdong Province saw the installed capacity of its small hydropower stations increase by 1.23 GW, involving RMB 69.14 billion of investment, of which over 50% was private capital. In some counties in Hunan Province private capital accounts for 86% of the total investment. However, at the national level private investment in rural preliminary electrification through hydropower is only about 7.8%.[38] Among the funds for small hydropower development between 1996 and 2002, only 14% came directly from the central

[37] Electricity is chosen as the substitute fuel for cooking due to the abundance of water in these areas and the difficulty, and thus high cost, of transporting alternative fuel sources (e.g., LPG) to these remote rural communities.

[38] See *Rural Electrification in China*, pp, 136-148.

government, whereas 45% came from bank loans; 28% from local governments, 4% from direct foreign investment, and 9% from other sources.[39] Multiple investment sources not only relaxed financial constraints of the central government, but also sped up the rural electrification process.

Joint-venture or share-based cooperation is the major form of financing. Cooperative investment is made by enterprises of the water sector and those from the electricity sector; by provincial and county investment companies and private enterprises; by private enterprises; and by foreign investors. Contributions come in various forms, including capital, land, labor, equipment, technologies, construction cost, and even the rights to water resources. Private enterprises only participate in power generation, while government or state-owned enterprises are responsible for grid construction.

V. Major Challenges for further Rural Electrification in China

China has been highly successful in electrifying rural areas over the past half century. Yet there still exist many challenges that China must face in its efforts at complete rural electrification.

5.1 Major challenges

The government's new targets for rural electrification are ambitious and barriers will have to be overcome, including technological institutional, social and environmental.

[39] China Power Yearbook, 1993-2003. While the bank loans of the state-owned banks (e.g. the Agricultural and the Commerce and Industry banks) are considered separately from direct central government funds, these loans do reflect the priorities of the central government. Furthermore, these loans cannot always be treated as purely commercial loans, since many borrowers do not repay their loans or only pay back interest on the loan. This is part of a general trend in the Chinese banking sector and is cause for concern regarding the future viability of the banks and their ability to lend in this sector.

5.1.1 New targets for electrification by 2015

In the Tibet Autonomous Region, three counties still lack access to electricity. In the nation as a whole there are still 609 rural towns and over 9000 villages in which access to electricity has yet to be realized, and over four million households do not have electricity in their homes.[40]

According to national plans, by 2015 rural China should be fully electrified. In relatively developed regions, 99.9% of rural households should have electricity. This number is reduced to 99% in areas with a medium level of development. In underdeveloped regions, the household electrification rate should reach 98%. In wealthier regions, per capita annual consumption is set at 1800 kWh. The numbers are 1300 kWh and 900 kWh for medium level and underdeveloped regions, respectively. Supply reliability should reach 99.9%. Electricity transmission and dispatch networks of 110 kV should be formed to realize highly automatic and modern management of grid and transformation station management (RED, 2001).

These targets are ambitious, although the increase in access rate is less than one percentage point. The major challenge lies in the fact that most households without electricity are located in remote, isolated, and in some cases not easily accessible mountainous and semi-desert nomadic regions. Further increases in access can be formidable; extension of national and even local power grids is not economically viable. Distributed supply of electricity through micro hydro, solar and wind power can be cheaper than extending large-scale power grids, though these options are also expensive. There are very limited opportunities for households here to earn adequate and regular cash income to pay the cost of electricity supply. And there is a lack of technical capacity to operate and maintain the distributed power systems.

Electrification targets for wealthier regions of the country are easier to reach, even though they are much higher than those for the medium level and underdeveloped regions.

[40] China yearbook of electricity industry, 1993-2003.

The biggest electrification challenge lies in the remote, underdeveloped regions. Access in these areas will not be possible through the grid system. Depending on local resources, distributed generation options (e.g., solar panels or micro-hydro generators) could be used to meet some basic needs. In addition, further rural to urban migration may also reduce the population without electricity access and the number of people for whom it will be expensive to provide electricity.

5.1.2 Quality of electricity service

With the completion of reform and renovation of rural electricity systems, the quality of electricity supply has improved substantially. In areas covered by the national grid, the quality issue may not be a big concern as management is under a unified system. However, problems could occur where there is a shortage of power supply. In the past, rural households and industries were the first to be cut off. For local power grids connected to national ones, blackouts may also be avoidable as excess power can be sold between local and large grids.

Electrification in remote rural areas is normally achieved via small hydropower, solar and wind power. These energy resources are renewable and clean, but face constraints of limited quantity and seasonal variation. Large power grids cannot help, as many of these small power stations are too remote to be connected. Bio-fuels (e.g., through gasification) could be an alternative, but policy efforts are needed to encourage the development of bio-fuel programs.

5.1.3 Institutional harmonization

There are many semi-government and government players in the rural electricity sector, including national power companies, the Ministry of Water (responsible for small hydro development), and the Ministry of Agriculture (largely responsible for bio-energy,

mini-hydro and solar power).[41] NDRC controls development planning, strategic investment and development coordination. Most fiscal policies are determined by the Ministry of Finance.

Conflict of interest. Rural electrification is encouraged, but there are a number of actors, creating the potential for conflicts of interest. For example, surplus electricity generated by less expensive small hydropower during the rainy season is often refused for connection to local and large power grids in favor of operation of their own power plants. This can impact the viability of local generators which play a large role in rural electricity supply and drive up the cost of rural electricity.

Inconsistency of policies. Government policies change over time. The government once granted full ownership to investors, but in the institutional reform process after 1997 many rural dispatch systems and power stations were required for free transfer of ownership to large power companies.

Institutional complexities. There exists an overlap of responsibilities among the government players in the management of rural electrification. Central, provincial and county governments all contribute to rural electrification, but it is not clear who is ultimately responsible for its operation and management.

Following reform and renovation, rural electricity supply now lies with large power companies and the role of local government is reduced. However, in the case of small hydropower, local governments at the county and township level often dictate the management structure.

[41] The national power companies are state owned companies that have monopoly power over electricity supply, including national State Power Company, National Grid Company (with some coordinating power over regional power companies), and regional grid companies. All these companies were part of the Ministry of Electricity, which was dismantled in 1998 restructuring of the government ministries. These national and regional companies enjoy semi-governmental status under the current system in China.

5.1.4 Rural poverty

The biggest challenge to further rural electrification is poverty. Electricity both contributes to and is constrained by rural development. Electricity has to be supported by at least cost recovery, if not profit. Without road access, education and healthcare, access to electricity often fails to lead to increases in welfare.

Rural poverty in China has been reduced continuously and substantially, yet poverty alleviation becomes more difficult as the easier cases are resolved. As urbanization leads to a decline in the rural population, wealthier rural areas and wealthier households are shifted to the urban sector; there is a rural brain-drain and capital outflow that accompanies urbanization.

5.1.5 Environment and climate change

Coal is the dominant source of energy in China; over 80% of China's electricity comes from burning coal. Emissions of SO_2 and other pollutants from power plants pose serious environmental concerns. As a developing country, China is not required to limit emissions of greenhouse gases (GHGs). Yet China is the second largest GHG emitter in the world, accounting for 14.9% of the world total in 2003 (IEA, 2005).

Soil and water erosion due largely to deforestation is recorded in most of rural China. The consequences include increased runoff, decrease in water flow, and sedimentation of reservoirs that reduce the life of hydropower facilities. Providing electricity for cooking can reduce the pressures that drive deforestation, but it takes time for natural vegetation to recover.

Climate change in turn affects hydrological patterns and can contribute extreme climate events in China (Qin Dahe et al., 2005). In northern and central China, rainfall has decreased over the past several decades. This will reduce China's hydropower potential. The frequency and intensity of rainstorms and severe droughts have also been higher, which can have a devastating impact on hydropower.

5.1.6 Financial Performance of Small Hydro Facilities

Many of the challenges discussed above create an overall financial problem for many small hydro enterprises. The policies designed to ensure financial viability are in conflict with other policies at the state level as well as with local priorities and institutional pressures. Conflicts with the larger state grids over distribution, diversion of SHP revenues by local governments to other programs, water use restrictions and a host of other pressures reduce the revenues and/or profits of these enterprises while they remain responsible for on-going loan repayments (see textbox below for an example from Hubei). A small survey of SHP facilities (~60 plants) done by the Ministry of Water indicated that nearly all of them had tariff rates below their long-term costs.[42]

While the circumstances (particularly of the local governmental merger) of this story are unique, the overall pattern appears to be common in some regions of China. The takeover of the systems by the regional grid companies occurred throughout China. Numerous bank loans are not being repaid in full (often just the interest is being paid) but collateral is not being seized. This is due to the fact that the state banks are obligated to loan in these rural areas and many of their other lending opportunities offer even worse returns while at the same time the assets put up for collateral (e.g. government buildings and coal mines) are not easily resold to recoup losses. (Interview, Liu Jinghe, Ministry of Water). However, this story must be contrasted with the success that other SHPs have had in maintaining a solid business model (for example, in Zhejiang province, where many SHP facilities are able to sell their power to the larger utilities at very favorable rates due to the power needs of nearby industrial centers).

[42] Liu Jinghe presentation to CASS-Stanford workshop, March 2005.

Box 2 Institutional Pressures on a Small Hydro Facility in Hubei Province

The Tian Shen Giao hydropower plant in Ye San Guan Township, Badong County, Hubei Province, is an example of the institutional problems that have arisen in the rural electrification process. The plant was commissioned and built in the 1990s by the local government, with loans from an agricultural bank covering 70% of the cost and the other 30% coming from local coal mine revenues. The plant was designed with 2.5 MW of capacity plus a local distribution network and the price set by the local price bureau was based on a cost-plus accounting method, ensuring financial viability (consumers paid 0.58 Yuan/kWh).

However, two major changes (unrelated but occurring in roughly the same time period) completely changed the economics of this power plant. First, in the reform process of 1998-1999 the business model was completely subverted. The provincial grid company extended their network into the area of this local utility and took over the local distribution system. The SHP is now forced to sell to the grid company at an average of 0.125 Yuan/kWh (maximum 0.17 Yuan/kWh depending on water conditions). However, the grid company is not obligated to buy electricity from the SHP.

Second, the local government that originally built the plant merged with another local government at a time when only the first phase of the project was completed (1.25 MW out of the 2.5 MW planned). The remaining funds from the loan were folded into the new government's budget and never disbursed for building the second phase. However, the SHP is still obligated to the bank for the full amount. The result of lower than expected generating capacity and lower than expected revenues due to

5.2 New opportunities

Many opportunities for furthering rural electrification arise from the overall development of the Chinese economy. In drafting the 11th five year plan (2006-2010), the Chinese Communist Party Central Committee (CPC, 2005) at its fifth Session of the 16th Congress envisaged a smooth and dynamic period of economic growth.[43] Key targets include, among others: (1) doubling the 2000 per capita GDP by 2010; (2) reducing 2005 energy intensity by 20% by 2010; (3) encouraging the market economy; (4) reducing

[43] The decisions were agreed upon November 11, 2005. See People's Daily November 12, 2005. The Communist Party in China plays a leadership role in China and the government follows the decisions made by the CPC. Therefore, the CPC documents have legal status for implementation.

poverty; and (5) improving the quality of life for both urban and rural populations. The guiding document by the CPC for 11th five year plan is highly consistent with the development of the rural electricity market.

More specifically, the government has voiced a preferential policy supporting rural development. Such a policy package includes the abolishment of agricultural taxes, the gradual provision of free schooling for primary education, financial transfers to the rural population, and rural infrastructure construction. The growing gap between urban and rural will be narrowed through harmonized development and reform. This would suggest an increase in rural incomes and a resultant increase in electricity demand.

Urbanization is projected to continue at an average rate of one percent per year (NDRC, 2005). This means that each year there will be over 13 million rural people moving to cities. With fewer people in rural areas, resources can be more focused and impacts can be larger.[44]

Energy security and energy conservation encourage additional resources for energy development in rural areas. There are several reasons for this. First, the Chinese government has enacted a new law on renewable energy.[45] The law requires that incentives be provided to promote the development of renewable energy. Solar, biomass, wind and small hydropower tend to be most plentiful in rural areas. Second, the government requires power companies to have a certain percentage of electricity from renewable sources. Large power companies have the necessary capital and technology for solar, wind and hydropower development. Investment in renewable energy will provide employment and income to rural population. Third, outdated technologies in rural areas are highly inefficient and incentives for energy efficiency will bring investment to rural regions for quality production and supply of electricity.

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[44] The urban sector generates larger revenue than the rural one and hence more resources would be availed for rural development. This has been demonstrated by the recent abolishment of agricultural taxes in 2005 and by the decision to provide free education at primary school in rural areas in 2006.

[45] Law on Renewable Energy, passed in February 2005 and put into effect in January 2006.

Environmental pressures are both challenges and opportunities. On the one hand, more investment will be targeted toward ecological rehabilitation to improve agricultural productivity. And conservation will require more substitution of commercial energy for fuelwood, as well as reforestation. In addition, mitigation of greenhouse gas emissions is included in the 11th five year plan (CPC, 2005) and rural energy sources will play an increasingly important role not only in electrification but also in controlling greenhouse gas emissions.

Last but not least, the capacity for electricity generation in China has been increasing substantially in recent years, at over 30 GW per annum (Zhang Guobao, 2005). Nonetheless, a serious shortage of electricity is likely to strike in the next two or three years. However, a balance between demand and supply should be reached in approximately five years. With sufficient electric power generation capacity, power grids will continue to penetrate rural market and deepen rural electrification.[46]

VI. Discussion and Conclusions

Rural electrification in China has been very successful, especially given China's level of economic development, which, while growing fast, remains quite low by global standards. The relationship between rural development and electrification is complicated but the government played a key role in making the two mutually reinforcing. As the rural electricity market is no longer isolated, the drivers for rural electrification are now different from the drivers that existed under a system of central planning. Small hydropower will continue to play a large role, but it will be part of the market with respect to investment and management. Along with urbanization and industrialization, the future of rural electrification will be further integrated into a regional electricity market.

[46] news.xinhuanet.com/politics/2005-11/10/content_3759992.htm

6.1 Rural electrification and development

Rural electrification does not necessarily promote rural development, nor does development automatically result in electrification. Rural electrification has to be driven and supported by a series of social, economic and environmental factors; as a single catalyst, rural electrification's potential is very limited. Associated investments are equally important, including those in energy resources, transportation, processing capacities, agricultural activities, market creation, credit, marketing, and promotion services, as well as equipment and backup for energy utilization. In addition, education, health, and other basic needs are also preconditions for regional development.[47]

6.2 The driving forces for further rural electrification

In the early stages of rural electrification in China, electrifications standards were low and rural electrification underwent rapid expansion due to government support and the promotion of preferential fiscal, taxation, financial, and other policies. After the completion of preliminary electrification, what will be the motivations for further rural electrification? During the preliminary stage, China was still under a planned economy and the transition from planned to market economy. During the deepening stage, electrification will be carried out under an established market economy system and administrative intervention instruments will be partially replaced by market adjustments.

The degree of rural electrification mainly depends on rural economic development, the price of electricity relative to other energy sources, and technological progress. The level of rural economic development and farmer incomes will become the driving force for deepening rural electrification. A higher degree of electrification will further boost the income of farmers. In some regions of the country, there is a move to a more market based electric power system with electricity prices jointly determined by effective electricity supply, effective demand, and the prices of other energy resources. The

[47] UNDP/ESCAP. Linking Rural Electrification With Rural Development in Asia [R]. 1990.

objective of electricity supply enterprises is profit maximization. Technological progress is a main driving force for deepening rural electrification. Advanced electricity generating technologies and transmission and dispatch technology can improve energy conversion efficiencies and increase electricity supply. Advanced production equipment can improve productivity, increase output, and lead to income growth; all these factors can increase electricity consumption. The utilization of new electrical appliances represents improvement in electrification degree.

6.3 The strategic position of rural small hydropower

In more than 50 years of China rural electrification, rural small hydropower has always played an important role in remote rural areas. Without rural hydropower, simply relying on large grids, China's rural electrification would not have experienced such rapid development.

In 2003, the total installed capacity of small hydropower was 31.20 GW, representing only 24.3% of the total technologically exploitable quantity. In western China, the total small hydropower utilization is currently only a little more than 9 GW, accounting for 12.1% of the technologically exploitable potential of small hydropower in the region.[48] In the next ten years, before rural electrification via large-scale grids is generally realized in China, vigorously developing small hydropower in rural areas is still the most viable option for increasing rural electricity supply.

However, small hydropower is also associated with some inherent disadvantages. The scale of electricity production from small hydropower is small, leading to high unit investment cost and lacking economies of scale. Seasonal and yearly variation is unavoidable while demand and consumption are more constant over time.

[48] China Yearbook of Electricity Industry, 1993-2003.

6.4 The future of rural electrification in China

Access to electricity will not be a primary goal for rural electrification. Rather, deepening of electrification in terms of an increase in quality of supply and quantity of consumption will be the major feature.

The future of rural electrification will be more dependent on the market than government control. Large power grids will dominate the rural electricity market. Local and distributed power generation can hardly compete with large power companies, but they can complement rural electricity supply. The Ministry of Water and Ministry of Agriculture played an important role in the historical process but they have been gradually withdrawing from the rural electricity market. Investment will come from a variety of sources, driven by market forces.

6.5 Issues for further investigation

Some understanding has been gained through a comprehensive review of the historical process of rural electrification. However there are still many more issues that require further studies. Key issues include: (1) econometric analysis of electricity demand in rural areas by examining the relationship between income, price of electricity, price of substitutes and other related factors; (2) regional variations and comparisons of China's rural electrification; and (3) the future of rural electrification in China.

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Appendices

Appendix A Explanatory Notes

This appendix explains some of the terms used in the main report.

Contents

1 Definition of rural/agricultural

Rural areas: Conventionally, the definition of rural areas is given by county and below county, an administrative and geographical region in which all sectors were considered part of the rural economy. Before 1978, the non-agricultural population in counties was very small. Industrial sectors were undeveloped or under-developed. In contrast, cities were dominated by industrial and service sectors with small agricultural population in the suburbs. This "county-level and below" definition has been used by the Ministry of Agriculture and the Ministry of Water until now. However, the China Statistical Bureau does not use this definition in their reporting. Employment and current residence are the source of information in NSB reporting. In many counties, industrial sectors are highly developed and therefore non-agricultural enterprises in these counties are counted as urban/non-agricultural.

For the purposes of this paper, we have tried to consistently use the term "rural" only when data comes from the NSB. Data from other sources is identified as "County-

level and below." The latter would include major county towns and industrial enterprises. The term "rural" is also used when making general references to more rural areas of China (though these could include county-towns). This confusion is, unfortunately, unavoidable, given the varying definitions.

County and below county level: In Chinese administrative organizations, provinces are made up of counties; in between a layer was added as prefecture. As urban/industrial administrative entities at the county level develop much stronger economies, they are given a prefectural level city status and a few counties are put under its administration. In theory this administration is not a "county" but a city or urban economy. In many other cases, if a county is highly developed industrially it is also turned into a city with the permission of the State Council. Therefore, there are many "county" level cities. These "cities" should also be excluded from the category of "counties" though in reality nothing changes with respect to administrative areas, population and urban structure.

In the Ministry of Agriculture (MoA) and Ministry of Water (MoW), the statistics still count "county" level cities and also the counties within the jurisdiction of a prefectural/provincial level municipal government. As a result, the statistics from the NSB and MoA/MoW do not overlap.

County level: County level often refers to the town in which the county government is located and the enterprises that under the direct administration of the county. That is, rural township and village enterprises are excluded from county level statistics.

Below county level: all other townships, excluding county level entities. All the township and village enterprises (TVEs) rural villages and towns (sometime can be large, over 50,000 population).

2 Township and village enterprises (TVEs)

All the enterprises in the non-agricultural sectors that are not located in urban part of the cities. From the late 1970s until the end of 1990s, they represented one of the most dynamic parts of the economy and a major source of economic growth and employment. As private ownership was not encouraged, all TVEs were collectively owned and managed by rural villages and rural townships. After the mid-1990s, most TVEs were privatized. Similarly, many small and medium state owned enterprises have also been privatized. As a result, the NSB does not have such a category of TVEs but in the MoA/MoW statistics, information on TVEs is still gathered and reported. However, TVEs are now a geographical category rather than a reference to ownership /management.

3 Statistics on Hydropower

There are no accurate statistics on small hydropower, principally for two reasons First, the change in the definitions of sizes in terms of installed capacity and power transmission facilities. Second, the division of labor for the management of small hydropower.

(1) Ministry of Agriculture: it was once responsible for small hydropower development but this power was largely taken over by the Ministry of Water. However, micro-hydro or mini-hydro are still under the ministry of agriculture, together with small wind mills, solar PVs, bio-gas electricity, etc.

(2) Ministry of Water: this ministry was once in charge of water and electricity. When electricity was taken out, small hydro was kept under its control and management. However, the 1998 reform and renovation of rural power systems led to the surrender of many small hydropower systems to the National Power Companies. Nevertheless, the MoW is responsible for rural small hydropower development and rural electrification through small hydro.

(3) State Power Companies (SPCs): They were under the former Ministry of

Electricity and are now under a few state-owned regional power companies. Almost all of the large power plants are under SPC management. In the 1998 Rural Electricity Reform and Renovation Process, many of the county and rural town level power plants were taken over without compensation.

Table A1 Historical development of small hydro

	Def. By size (MW)	Total inst. (MW)	Elect. Gen. b kwh	Units and operation	Power transmission	Uses of electricity
1950s	<0.5	0.15		Iron & wooden turbine, single station	400V, local use	lighting
1960s	<3.0	0.73		Molded iron turbine, multiple station connected	10 kV	Lighting & food process.
1970s	<12.0	6.33		Series units, partial auto control	35 kV, county local grids	Lighting, food process. Irrig., county enterp.
1980-90s	<25.0	10.10	29	High efficiency units, automatic operation	110 kV, local grids	County level electrificati on
2003	<50.0	31.20	110	High efficiency units, automatic operation	110 kV, connected local grids	Regional electrificati on

Source: Liu Jinghe, 2005, Zhang Chao, 2005, p. 183-5).

4 Statistical inconsistencies

Rural population: there are two sets of statistics. One is by the statistical bureaus and the other is by household registration provided by local police stations (public security offices). Before the mid-1980s, there was hardly any unofficial migration, in particular from rural to urban areas under the household registration system which was introduced in the early 1950s. Under this system, population was divided into two groups: agricultural (rural) and non-agricultural (urban, including those in townships non-agricultural sectors). Since the reform and open-up policy, a large “agricultural”

population has been flowing to urban areas for employment. The majority of these migrants are on a temporary basis, working in the non-agricultural sector for a few months a year or a few years only. Their household registration does not change.

The Official Statistical Bureau uses census and sample survey data, which count temporary migrants as local residents (but they do not have the entitlement to education, healthcare and other social services in urban areas). The Ministry of Agriculture and Ministry of Water use the data based on household registration. In general, the statistical bureau gives a higher number for the urban population while the other data shows a larger proportion of the rural population. The difference can be over 150 million.

Table A2 Discrepancies of rural population (in millions of people) between different sources

Year	China Statistic Bureau	Household registration	difference	total population	difference/total pop (%)
1990	895.9	841.4	54.5	1143.3	4.8
1995	902.3	859.5	42.8	1211.2	3.5
2000	928.2	808.4	119.8	1267.4	9.5
2001	933.8	795.6	138.2	1267.3	10.9
2002	935.0	782.4	152.6	1284.5	11.9
2003	937.5	768.5	169.0	1292.3	13.1
2004		757.1		1299.9	

Source: (1) National Statistic Bureau: Statistical Yearbook of China, various years.

(2) household registration: 1990: Rural Statistic Yearbook of China (by Statistical Bureau of China); 1995 and onwards: China Agriculture Statistical Report, by the Ministry of Agriculture, China Agriculture Press, various years.

5. Exchange rate of Renminbi

The monetary unit in China is Renminbi. In interpreting its par value, one has to take care as the exchange rate has been subject to management and changes since 1950.

1 1949-1952: the rate was not fixed but under strict regulation by the government.

2 1953-1972: Renminbi was pegged to the Soviet Ruble.

3 1973-1980: Renminbi was pegged to a basket of currencies.

4 1981-1993: dual exchange rates were applied. For the period between 1981 and 1984: The official rate to the outside was: $1.0 = RMB1.5; Domestic settlements: $1:00 = RMB2.8. From the period between 1985 and 1993: in addition to official rates, there was an officially managed market for exchange of foreign currencies and the "market" rate was continuous depreciation of the RMB.

5 1994-2005 (20 July 2005): official pegged to the US dollar at 1$.0 = EMB8.27.

2005 21 July 2005): pegging to a basket of currencies and the rate to the US dollar is changed to: $1.0 = RMB8.11. Market rate in September 2005 is between $1:00 = RMB8.05.

Appendix B: Notes on statistics

This appendix provides some statistical data on rural electrification and related issues.

1. China Statistical Yearbook. Compiled by National Statistic Bureau and published by the China Statistical Press. This is an annual publication providing an overall and comprehensive picture of activities in China.

2. China Rural Statistical Yearbook. This is from the Ministry of Agriculture and published by China Agriculture Press, also on an annual basis. Much of the information is on rural social and economic features, with limited information on rural energy and electricity. The statistical data are not consistent through years, with indicators and measurements changing over time.

3. China Yearbook of Electricity Industry. An annual product compiled by the Ministry of Electricity and later by the National Power Company and published by the China Electricity Press. Institutional reform brings about changes in functions and jurisdictions. As a result, indictors and definitions can be highly inconsistent. The publication started in the early 1990s with inadequate information on historical development.

4. Other related publications (see reference section of the main report).

As the numbers are from various sources and different years of statistical yearbooks, they are not necessarily consistent and some can be missing. Furthermore, numbers for the same year can vary and they themselves are not consistent even from a single source of statistics. No efforts have been made to harmonize the sources of information. Nevertheless, the numbers are indicative of the direction of change and in the right magnitude. The reasons for such inconsistencies include:

1. Change of administrative functions by related government bodies. In particular,

electricity, water and coal were under different ministries and later some of them were turned into state owned corporations like coal and electricity but still with some administrative power. The functions performed by the Ministry of Water have been substantially reduced.

2. Change of administrative boundaries. In the past few decades, some prefectures and counties disappeared while others emerged. Some counties were turned from rural counties into cities. As a result, double counting and omissions are unavoidable.

3. Strategic manipulation of data. Rural electrification is good for rural development and for rural residents. It is also a measurement of performance for government officials for promotional purposes. As a result, it is not unusual to have some numbers "manufactured" rather than surveyed.

4. Technical reasons: In some years a few indicators are included while in other years they are not. The definition of items also changes. For example, the size of small hydro has been changed several times. Therefore, care has to be taken in interpreting the numbers though they are indicative of the trend of rural electrification. That is the key reason they are not included in the analysis of the main report. Instead, they are presented separately in this appendix.

Table B1 Electricity and rural development, 1978-2004.

	Electricity Consumption (All China) (kwh/capita)	Rural Electricity Consumption(kwh/capita)	rural/total (%)	Rural Electricity Consumption (TWh)	Income Rural/Urban (%)	Rural Hydropower Generating Capacity (MW)	Total Electricity Consumption (TWh)	Rural Population (billions)	Rural Income (RMB/capita)	Urban Income (RMB/capita)
1978	268	32.0	9.9	25.31	0.39	2284	256.6	0.79	133.6	343.4
1980	306	40.3	10.7	32.08	0.40	3041	300.6	0.80	191.3	477.6
1985	391	63.0	12.4	50.89	0.54	3802	410.7	0.81	397.6	739.1
1990	547	100.4	13.6	84.45	0.45	4288	621.2	0.84	686.3	1510.2
1995	836	192.6	16.4	165.57	0.37	5195	1007.0	0.86	1577.7	4283.0
2000	1074	299.5	17.9	242.13	0.36	6985	1355.6	0.81	2253.4	6280.0
2004	1687	519.5	18.0	393.30	0.31	9938	2187.0	0.76	2936.4	9421.6

Source: China Statistical Yearbook, Various years.

Table B2 Electricity Development (County-Level and Below), 1987-2002

	1987		1994		1997		2000		2002	
(1)Rural capacity	Mw	%	Mw	%	Mw	%	Mw	%	Mw	%
Total	15930	100.0	32090	100.0	43830	100.0	46130	100.0	51680	100.0
Small hydro	10660	66.9	15770	49.1	20410	46.6	23800	51.6	26760	51.8
Small thermal	2330	14.6	8180	25.5	14040	32.0	16270	35.3	18420	35.6
Diesel	2900	18.2	8060	25.1	9270	21.1	5740	12.4	5980	11.6
Renewable	40	0.3	80	0.2	120	0.3	320	0.7	510	1.0
(2)Rural generation	Twh	%	Twh	%	Twh	%	Twh	%	Twh	%
Total	39.9	100.0	98.9	100.0	126.9	100.0	154.8	100.0	186.2	100.0
Small hydro	27.7	69.4	54.3	54.9	62.0	48.9	77.2	49.9	91.8	49.3
Small thermal	10	25.1	38	38.4	56.8	44.8	69.9	45.2	83.6	44.9
Diesel	2.1	5.3	6.5	6.6	8	6.3	7.6	5.0	10.1	5.4
Renewable	0.1	0.3	0.1	0.1	0.14	0.1	0.1	0.0	0.789	0.4

Source: China yearbook of electricity industry, 1993—2003.

Table B3 Rate of access and no access to electricity: counties, townships, villages and households

	Rate of access to electricity %			No access to electricity (numbers)				
	townships	villages	households	Counties	townships	villages	households mil	Population mil
1993	97.4	93.0	89.6	26	1269	54858	25.01	NA
1994	97.8	95.0	91.3	16	1071	37151	22.14	NA
1995	98.3	96.1	93.3	16	828	29783	17.31	NA
1996	98.6	96.7	94.7	11	649	24818	14.04	72.00
1997	99.0	97.7	95.9	10	442	17462	11.07	NA
1998	99.2	98.1	96.9	8	364	14042	8.81	50.00
1999	98.3	97.8	97.4	7	766	16509	7.06	NA
2000	98.5	98.2	98.0	NA	NA	NA	NA	NA
2001	98.6	98.5	98.4	3	629	10952	4.78	NA
2002	98.5	98.7	98.5	3	608	9303	4.58	NA

NA: not available.

Source: China yearbook of electricity industry, 1993—2003.

Table B4 Mode of electricity supply (number of counties), 1995-2000

	Large grids	Wholesale	Small hydro	Small thermal
1995	707	996	567	79
1996	716	1004	571	81
1997	727	1005	580	66
1998	775	1065	513	35
2000	854	1131	433	20

Note: in other years, numbers were not reported. The numbers provide an overall picture of the sources of electricity supply. The number of counties by national grids (large grids and wholesale) has been increasing while distributed independent supply by small hydropower and small thermal has been in rapid decline. Nevertheless, small hydro and small thermal are also in existence in the first two categories but they do not represent the dominant source of power supply.

Source: China yearbook of electricity industry, 1993—2003.

Table B5 Electricity consumption and uses (county-level and below)

	Total Rural Electricity consumption			By rural region				By uses					
	Bil kWh	over previous year %	over national total %	Below County-town		County town		Industrial/service		agricultural		Households	
				Bil kWh	%	Bil kWh	%	Bil kWh	%	Bil kWh	%	Bil kWh	%
1993	294.0	12	35	151.8	51.6	142.2	48.4	173.8	59.1	69.0	23.5	51.3	17.4
1994	336.0	14.3	37.1	172.2	51.3	163.8	48.7	199.9	59.5	75.4	22.4	60.7	18.1
1995	377.9	12.5	NA	195.5	51.7	182.4	48.3	225.0	59.5	81.8	21.6	71.2	18.9
1996	408.8	8.18	38.7	212.4	51.9	196.4	48.1	242.6	59.4	88.5	21.7	77.8	19
1997	435.9	6.63	40.2	228.6	52.4	207.3	47.6	253.8	58.2	96.9	22.2	85.2	19.6
1998	459.9	5.51	40.53	240.1	52.2	219.8	47.8	268.2	58.3	78.0	17.0	93.8	20.4
1999	498.2	8.31	41.20	262.7	52.7	235.4	47.3	292.6	58.7	103.7	28.9	102.	20.5
2000	566.9	13.79	42.75	292.1	51.5	274.8	48.5	347.0	61.2	105.7	18.6	114	20.2
2001	625.9	10.41	43.05	na	na	Na	na	386.5	61.8	117.5	28.6	122	19.5
2002	721.2	15.24	44.06	366.3	50.8	354.9	49.2	465.1	64.5	124.7	17.3	131.	18.2

Source: China yearbook of electricity industry, 1993—2003.

Note: The column for total rural consumption includes all consumption in counties considered to be "rural." As discussed in Footnote 2, this can include areas that are no longer rural. This rural consumption total in this table is therefore further divided between consumption in the county-town and consumption outside the county-town. The latter matches more closely the rural consumption figures provided in Table B1, which are based on the Chinese Statistical Yearbook, where rural is defined according to employment and residency, rather than geography.

Table B6 Per capita electricity consumption (county-level and below)

	household kWh/c.y	Rural pop. kWh/c.y	Rural households kWh/c.y	Rural income Rmb/capita
1993	48	168	NA	921.62
1994	56.4	191	42	1220.98
1995	66	217	48	1577.74
1996	72	236	53	1926.07
1997	78	254	58	2090.13
1998	84.44	265.01	64.13	2161.98
1999	91.57	290.53	70.35	2210.34
2000	101.08	321.91	77.24	2253.42
2001	106.55	351.36	82.97	2366.40
2002	114.42	404.33	90.15	2475.63

Source: China yearbook of electricity industry, 1993—2003.

Table B7 Sources of investment in small hydropower (Millions of RMB)

Year	Total	Central Government	Loans	Foreign Direct Investment	Local Government	Other (electricity Levy, SHP Income, Private)
1996	14489	850	6519	809	4222	2089
1997	14565	833	6614	712	4230	2173
1998	15874	879	6907	267	5310	2508
1999	18768	2329	7377	1131	5505	2423
2000	25078	4375	10400	1378	6722	2201
2001	29166	3017	11085	8053	4975	2034
2002	24747	4535	11440	355	6132	2282
2003	30995	3585	11918	1047	10030	4413
total	173664	20407	72264	13756	47130	20126
%	100.0	11.7	41.6	7.9	27.1	11.6

Source: China yearbook of electricity industry, 1993—2003.

Table B8 Structure of electricity supply (county-level and below)

	Small hydro		Small thermal		diesel		Wind/solar /geothermal		Total capacity GW	electricity	
	Cap.	Elec.	Cap.	Elec.	Cap.	Elec.	Cap.	generation		Gross	Net (-20%)
	%	% gross	%	% gross	%	% gross	%	% gross		bil kWh	%of rural total
1993	52.3	53	24.1	37.1	23.4	9.8	0.2	0.1	28.8	88.7	24.1
1994	49.1	54.9	25.5	38.4	25.1	6.6	0.3	0.1	32.1	98.9	23.5
1995	47.6	51.4	28.3	41.7	23.9	6.8	0.2	0.1	35.0	107.8	22.8
1996	46.3	48.2	30.2	43.9	23.2	7.73	0.3	0.2	38.3	119.0	23.3
1997	46.6	48.9	32.0	44.8	21.1	6.3	0.3	0.1	43.8	126.9	23.3
1998	47.8	49.4	33.5	45.3	18.0	4.9	0.7	0.3	44.1	132.1	23.0
1999	48.2	49.3	33.3	43.7	17.9	6.7	NA	NA	45.4	138.6	22.3
2000	51.6	49.9	35.3	45.1	12.4	5.0	0.7	0.0	46.1	154.1	21.8
2001	50.1	48.8	35.6	45.4	13.3	5.5			49.2	167.1	21.4
2002	51.8	49.3	35.6	44.9	11.6	5.4	1	0.4	51.7	186.2	20.7

Source: China yearbook of electricity industry, 1993—2003.

Note: Small hydro and small thermal have been the main sources of rural power supply, particularly in remote rural regions. Recently, policies that encourage the shutting down of small thermal have been reducing the number of small thermal power plants for environmental and energy efficiency considerations. However, many small thermal power plants are still in operation for several reasons: (1) local protection as a key source of local government revenue; (2) insecure supply of electricity from large grids; and (3) seasonal variations of small hydropower production. Nevertheless, small thermal is on the decline.

Table B9 Composition of electricity supply and consumption (TWh)

	1990	1995	2000	2002	2004	1990%	2002%	2004%
(1)total supply	621.2	1007.7	1355.6	1640.5	2187	100.0	100.0	100.0
hydro	126.7	1905.6	222.4	288	328	20.4	17.6	15.0
thermo	494.5	804.3	116.4	1327.4	1807.3	79.6	80.9	82.6
nuclear		12.8	16.7	25.1	50.1	0.0	1.5	2.3
(2)total consumption	623	1002.3	1347.1	1633.2	2173.5	100.0	100.0	100.0
agri	42.7	58.2	63.7	77.6	61.2	6.9	4.8	2.8
industry	487.3	766	965.4	1179.3	1625.8	78.2	72.2	74.8
transport	6.5	16	15.5	16.4		1.0	1.0	0.0
construction	10.6	18.2	28.1	33.8		1.7	2.1	0.0
commerce	7.6	20	39.4	50	243.5	1.2	3.1	11.2
other	20.2	23.4	64.3	75.9		3.2	4.6	0.0
households	48.1	100.6	167.2	200.1	243	7.7	12.3	11.2

Source: China Statistical Yearbook，1990 - 2004. Numbers are for all of China.

Table B10 Elasticity of energy consumption

	growth rate of energy consumption %	Growth rate of electricity consumption	GDP growth rate	Energy consumption elasticity	Electricity consumption elasticity
1985	8.1	9.0	13.5	0.60	0.67
1989	4.2	7.3	4.1	1.02	1.78
1990	1.8	6.2	3.8	0.47	1.63
1991	5.1	9.2	9.2	0.55	1.00
1992	5.2	11.5	14.2	0.37	0.81
1993	6.3	11.0	13.5	0.21	0.70
1994	5.8	9.9	12.6	0.46	0.79
1995	6.9	8.2	10.5	0.66	0.78
1996	5.9	7.4	9.6	0.62	0.77
1997	-0.8	4.8	8.8	-	0.55
1998	-4.1	2.8	7.8	-	0.36
1999	-1.6	6.1	7.1	-	0.86
2000	0.1	9.5	8.0	0.02	1.19
2001	3.5	8.6	7.5	0.47	1.15
2002	9.9	11.6	8.3	1.19	1.40
2003	13.2	16.5	9.3	1.42	1.77

Source: China Statistical Yearbook，1985 - 2004. Calculation of elasticity is by the author.