

Rural Energy Patterns in China: A preliminary assessment from available data sources¹

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Abstract. This paper looks into the overall energy pattern in rural China and the possible reasons behind based on an assessment of available data sources. Commercial energy consumption by rural residents is disproportionately lower than that by their urban counterparts. Moreover, biological matters are the dominant source of household fuels in rural areas. Variations in energy consumption are closely related to differences in income, access to energy sources, structures of local economy and geographic/climatic conditions. Information on non-commercial energy consumption is incomplete and additional sample survey is required to gather details of rural energy consumption for specification and verification.

I Introduction

Like many other developing countries, China has a large rural population mainly engaged in traditional agricultural production. There are over 800 million people and over 245.1 million households in rural areas. Agricultural sector employs over half of the labour force and produces food for the whole nation. Township and village non-agricultural enterprises are also located in rural areas playing a vital part in the rural as well as national economy. In 2000, the share of agricultural sector in the economy is still as high as 16%².

The rural components are an integral part of the Chinese economy, providing vital labour and material inputs to the urban and industrial sectors. However, the focus of economic development in China has been on the urban part and industrial sectors with respect to investment and government policies, such as education, infrastructures, healthcare, and restrictions on mobility. This biased approach is well reflected in energy use in China. Before the opening up policy in the early 1980s, there was very limited access to commercial energy in rural areas. In particular, household energy consumption has been largely reliant on non-commercial traditional biological matters such as crop residues, fuelwood and biogas. In the official energy balance sheets, non-commercial energy is not included in the calculation (Zhou et al, 2002, CSB, 2001).

With large population and labour force in rural areas, rural energy issues are of particular concern for the decision makers. For poverty alleviation and improvement

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² There is a slight difference in statistical numbers between the Ministry of Agriculture (MOA, 2001) and China Statistics Bureau (CSB, 2001). Nevertheless, they are very close.

of rural living standard, there is an urgency to increase rural access to high quality and less polluting commercial energy. Although China has been the second largest greenhouse gas emitter in the world, the emissions in rural China are largely uncounted simply because commercial energy consumption is very limited. Along with the process of urbanisation and industrialisation, large part of the rural population will turn to commercial sources of energy. For those remaining in rural regions, increases in access to commercial energy will also have important implications in energy use and sustainable development.

Given the importance of rural energy as a component of the Chinese energy system, this paper intends to investigate into the overall picture of rural energy pattern. In section 2, the role and energy use in rural areas is described in the context of the overall Chinese economy. The following sections are designated to examine rural energy production and consumption patterns by fuel and by sector, and regional variations. Section 6 will look at the factors behind the energy patterns in rural China. An overall assessment of the data for this analysis is given in section 7 and conclusions and suggestions are presented in the last section.

2 Rural Components in the Chinese Economic and Energy Systems

The relative position of rural part in the Chinese economy has been on a steady decline. According to population survey data³, the share of rural population over the national total has reduced from 82.1% in 1978 to 63.4% in 2000. In terms of absolute numbers, however, there has been a slight increase in rural population over the same period, from 790.1 million to 807.4 million, due to population growth. A different set of statistics gives a higher share of the rural population, being 73.9% with an absolute number of 912.2million in 2000⁴. The difference of 105 million is due to temporary residence of rural people in urban areas, who spend part of their time in cities and part at their rural homes. There are regional variations in the proportion of rural residents among regions, but the figures fall between 45% to 80% in all the provinces with those of between 12%-28% for three provincial level municipalities (Shanghai, Beijing and Tianjin) as indicated in the population census.

The decline of the share by agricultural production over national economy is even more dramatic. In the early 1950s, the share of agriculture was as high as 50%. The proportion was around 1/3 during the first half of the 1980s. This number was reduced to 15.9% in 2000. Agricultural output in Shanghai, Beijing and Tianjin accounted well below 5% of their total output in 2000, as compared to figures of between 10% and 30% for the provinces. Total agricultural output⁵ in 2000 reached 1486.4billion

³ 5th national population census was undertaken in November 2000 with reference time point at zero hour 1 November 2002 (CSB, 2001, p. 91).

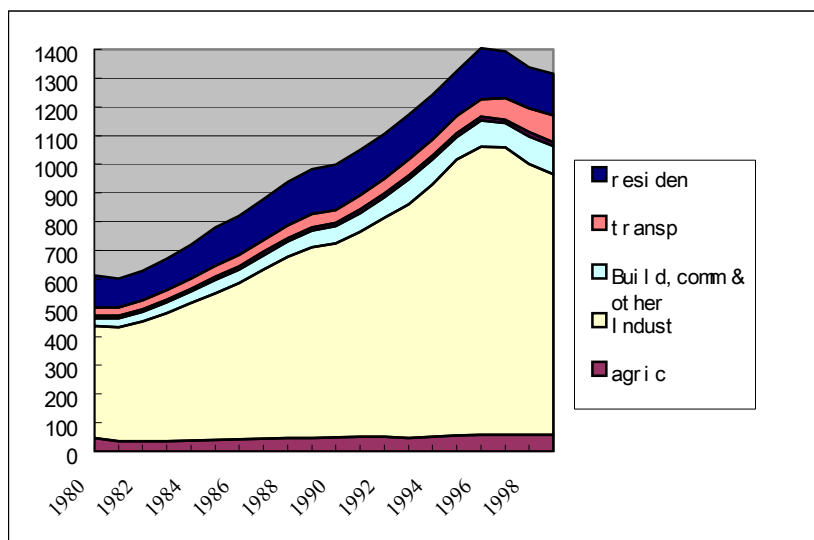
⁴ This figure used the household registration system which started in the 1950s to restrict population mobilisation between rural and urban areas (MOA, 2001, p.3).

⁵ Note that this figure from MOA (2001, p.9) is slightly higher than that reported in CSB (2001, p.49), which is 1421.2billion RMB. This figure covers crops, forestry, livestock and fisheries.

(1990 price) RMB (\$180b). Cropping is the dominant agricultural sector, accounting for 53.8% of the total, followed by livestock (29.79%), fishery (11.92%) and forestry (4.46%) (MOA, 2001).

Overall energy consumption in China has increased substantially from 602.8 million tons of coal equivalent (tce) in 1980 to 1301.2 million tce in 1999, at an annual rate of 3.92% over the period. However, total energy consumption reached a peak at 1389.5 mtce in 1996 and then remained relatively stable at 1.3 billion tce until the end of the last century⁶. Commercial energy consumption in rural areas is mainly used for agricultural machinery, irrigation and drainage, with limited residential uses. In the agricultural sector, consumption of commercial energy also experienced a similar trend of increase during the same period from 46.9 mtce to 58.3 mtce, but with much slower rate of growth, being only 0.47% annually. The share of agricultural consumption of commercial energy over the national total has been reduced from 7.78% in 1980 to 4.48% in 1999 (Figure 1). In comparison with the large share of population, labour force and GDP, use of commercial energy in the rural part of China is negligible, with 0.61 tce per hectare of arable land in 1999. Nevertheless, the actual consumption of commercial energy in rural areas may be higher as part of the consumption by rural industries, transport, commerce and households may be included in the non-rural sectors.

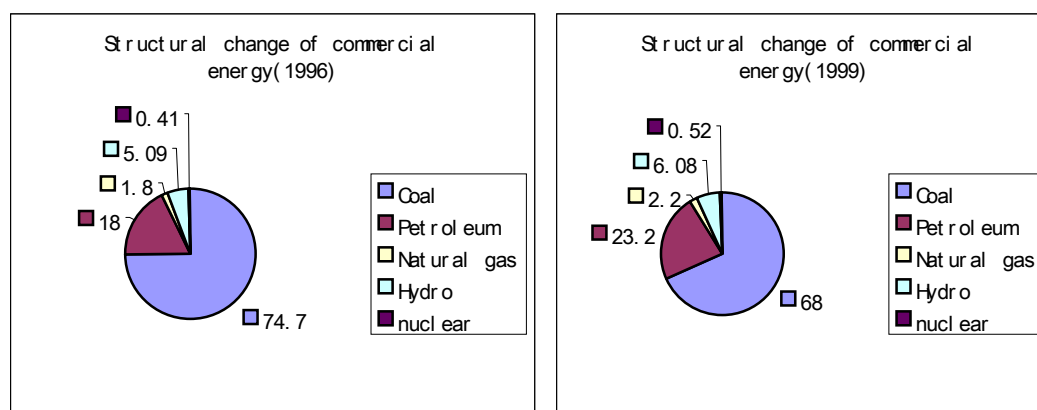
Figure 1 Consumption of commercial energy by sectors, 1980-1999 mtce



Note: Agriculture: including cropping, forestry, animal husbandry, fishery and water management; Transport: include: transport, post and telecommunication; Commerce: including commerce, catering, flow of materials, marketing and storage
 Source: Zhou & Wang (2002), p. 648, CSB (2001, p. 230).

⁶ The official statistics recorded a slight decline but this is questionable as much of the non-state sector production and consumption of coal was not reported to avoid possible punishment by the government who ordered shutdown of most of the no-state sector small coal mines. But the figure is now under adjustment to reflect the production and consumption of the unreported.

Figure 2 Structural change of commercial energy consumption, 1996-1999 (mtce, %)



Source: CSB-IT (2001, p.109)

In the mix of commercial energy, coal has been the dominant source of primary energy but its share has been reduced from over 3/4 to about 2/3 (figure 2). By contrast, consumption of oil products and electricity has been on a steady increase, from 19.0kg/c and 94.5kwh in 1965 to 168.1kg/c and 981.6kwh/c in 1999 respectively. This trend is even more evident in the household sector. For residential uses, per capita coal consumption in 1999 is 67.1kg, less than half of the level in the early 1990s. In case of electricity, per capita household use increased from 10.7kwh in 1980 to 118.1kwh in 1999, 10 times higher than 20 years earlier (table 1).

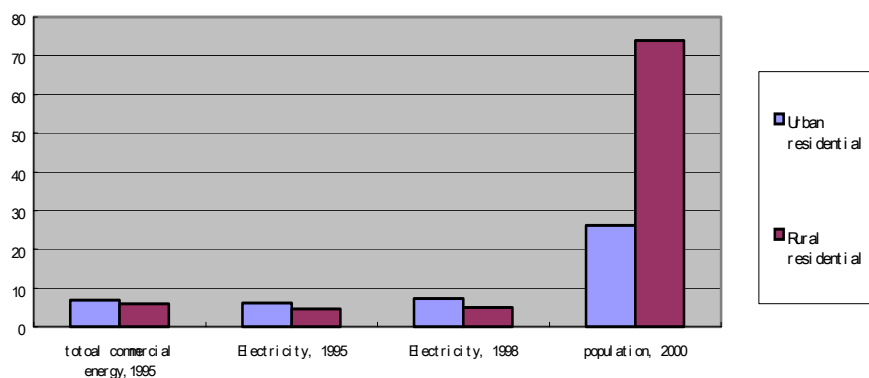
Table 1: per capita consumption of commercial energy: total and residential

	Total consumption		Residential consumption			
	total	electricity	total	Coal	Electricity	gas
	kgce	kwh	kgce	kg	kwh	m ³
1980	614.4	306.4	97.7	118.0	10.7	1.6
1985	734.1	394.2	127.5	149.6	21.3	1.7
1990	869.5	548.8	139.2	147.1	42.4	4.1
1991	901.8	591.3	138.1	142.0	46.9	4.7
1992	937.1	651.5	133.4	126.1	54.6	6.2
1993	984.3	715.1	130.6	120.5	61.2	5.9
1994	1029.8	777.0	129.3	109.5	72.7	8.0
1995	1088.7	831.9	130.8	112.3	83.5	6.3
1996	1141.2	884.1	145.5	118.3	93.1	5.5
1997	1123.3	917.3	133.1	99.5	101.8	6.6
1998	1064.4	933.7	115.9	71.5	106.6	7.9
1999	1038.0	981.6	116.1	67.1	118.1	11.4

Rural residential consumption of commercial energy accounts for a very small percentage of national total (figure 3). In 1995, rural and urban residents used 5.98% and 6.8% of the total commercial energy respectively, while the share of population in 1995 is 71.0% and 29.0% respectively. In per capita terms, each rural resident consumed 90.01kgce while the urban one used 250.28kgce. Raw coal was the major

source of commercial energy in rural areas. The gap between rural and urban is even larger in the consumption of electricity. In 1998, residential use of electricity was 69.6kwh per capita in rural areas and 229.5kwh per capita in urban areas (figure 3).

Figure 3 Proportion of total commercial energy, electricity consumption and population in rural and urban areas over the total



Source: Zhou & Zhou (2001, p. 133) and Zhou & Wang (2002, 320), MOA (2001)

3 Rural Energy Production

Under the command and control system, commercial energy was monopolised by the state sector. Capital and technology intensive energy production is beyond the capability of rural entrepreneurs even after 1978 when market reform was introduced. Owing to shortage of rural household fuels, the government relaxed control over coal mining and small scale hydro development in a few occasions. In addition to traditional fuel sources such as crop residues and fuelwood, rural households have been encouraged to use new and renewable energy sources, in particular biogas. Solar panels are sold for household water heating but few households are able to invest in wind energy. In northern China, greenhouses are widespread to make use of solar energy in winter for vegetable production.

Coal production in the non-state sector was under tight control and the output was kept low under the middle of 1980s. In 1949 when the People’s Republic of China was established, non-state mines produced only 1.45 million tons of coal, accounting for less than 5% of the total output. This rate was kept throughout the 1950s and 1960s. In the 1970s, restriction on non-state sector coal mining was relaxed due to shortage of rural household fuels. As a result of market reform and high demand for coal, non-state sector coal mining flourished and output rocketed from 106.31 million tons at the end of 1970s to 614.77 million tons in 1996, with 73000 village and township coal mines, employing over 20 million rural laborers (CREA, 2000, p.2). Coal production in the non-state sector was well over 40% in the middle of 1990s. However, this growing trend stopped in 1998. Due to low demand, change in industrial structures, unemployment in the state owned mines and safety considerations in the non-state mines, the government ordered shutdowns of small

coalmines in the non-state sector. In 1999, total coal production in the rural non-state coal mines reduced to 317 million tons, accounting for 31% of the total output (Zhou & Zhou, 2001, pp. 381-384).

Small and micro hydro power development in remote rural regions has been a major source of clean energy. In late 1950s, rural people's communes were encouraged to develop. As financial and technological capabilities were very limited, the rate of development was only some 15,000kw per year. In the 1960s, small hydro was highlighted to provide electricity for drainage and irrigation so as to meet the national goal of food self sufficiency. As fertile farmland is far away from mountainous hydro rich areas, however, limited resources were invested in small hydro power. In the 1970s, local ownership of small hydro was acknowledged and subsidies were provided to speed up rural hydro development for supply of electricity in rural regions. The size of small hydro station increased from 500kw in the 1960s to 12000kw, with an annual increase of 580,000kw. In the 1980s, the government announced to have 100 counties for rural electrification with an overall consumption of electricity of 150 -200kwh per capita and over 200kwh per households for residential uses⁷ using small hydro power. At the end of the last century, a total of 600 counties realised rural electrification. By the end of 2000, total capacity of small hydro power reached 30,000MW (Gu et al, 2001, p.205). According to the statistics by the Ministry of Agriculture (MOA, 2001, p.326), there are 90507 micro hydro power generators run by rural township, village and households, with a capacity of 167,740kw, generating 436.4mkwh, supplying 662926 rural households with electricity.

Crop residues have been the major source of fuel for rural household. The amount of output is estimated in proportion to the yield corresponding to different crops. Then the crop residue is converted to coal equivalent for comparison and statistical calculation. The conversion factors are given in table 2. The amount of straw for 1 kg rice is about 0.623kg while the ratio for corn is as high as 2. Each kg of rice straw is equivalent to 0.429kg of coal (ce) as compared to 0.571 kgce for cotton.

⁷ The conditions set for such a county include: (1) over 90% of the households have access to electricity for lighting and electric appliances; (2) part of the households replaces fuelwood with electricity for cooking for 6 months a year; and (3) the demand of electricity is met for agricultural production and rural industries. See Zhou & Zhou, 2001, p.392.

Table 2 Estimation of crop residue production (2000)

crop	output (mt)	residue/grain	residue(mt)	ce index	ce (mt)
rice	187.91	0.623	117.07	0.429	50.22
wheat	99.64	1.366	136.11	0.5	68.05
corn	106	2	212.00	0.529	112.15
other grain	11.77	1	11.77	0.486	5.72
beans	20.1	1.5	30.15	0.543	16.37
root crops	36.85	0.5	18.43	0.486	8.95
oilseeds	29.55	2	59.10	0.529	31.26
cotton	4.42	3	13.26	0.543	7.20
sugar cane	76.35	0.1	7.64	0.441	3.37
total			605.52		303.30

Note: Cop output is from MOA (2001) and conversion factors are taken from CAREI (2000, p.24).

According to a survey undertaken in 1996 (CREA, 2000, p.54-59), some 604 million tons of crop residues in 1995 were used for different purposes: 15% back to land as fertiliser; 25% as livestock foodstuff; 9% as industrial feedstock; 31.5% as household energy; 19.5% burned as waste in the field. Straw annual production at 600mt. Due to its multipurpose nature, only 30-40% can be used as household fuel, about 180-240mt (100mtce). This represents an overall picture of crop residue production and use as the variations among years can be minimal (table 2). Fuelwood has been overharvested during the past decades, but the sustainable yield level is at 158mt(90mtce) per year (Gu et al, 2001).

Another key source of bio-energy is biogas. It is estimated that human and livestock excreta in China would generate 4billion m³ biogas (about 30mtce) and supply energy for 12.35m rural households. Due to serious shortage of fuel and considerations for rural hygiene, biogas has been promoted in rural China and relatively successful. Owing to lack of commercial viability for large scale production, the actual use is only a small fraction of the resources (table 3). Solar, wind and geothermal are all in small scale and at early stage of development as a source for rural energy supply (table 3).

Table 3 Utilisation of renewable energy resources in rural China, 1998

	Capacity	Energy type	Production	Million t coal equ.	No households served m
Small hydro	22.02mkw	Electricity	55 bkwh	16.5	50
Micro hydro		Electricity	0.27bkwh	0.11	0.56
Household biogas	6.00m	Biogas	1.78bm3	1.27	5.76
Large/medium biogas	573	Biogas	0.03bm3	0.02	0.06
Solar water heater	7.89m m2	Warm water		0.95	7.00
Solar energy collector	6.47m m2	Heat		0.16	0.07
Solar stove	0.244m	Heat			0.24
Solar battery	516.4kw	Electricity		0.005	0.03
Geo-thermal	4735ha	Heat		0.99	
Windmill	18.1 k kw	Electricity	0.04bkwh	0.014	0.17
total				20.00	

Source: CAREI (2000), p.53.

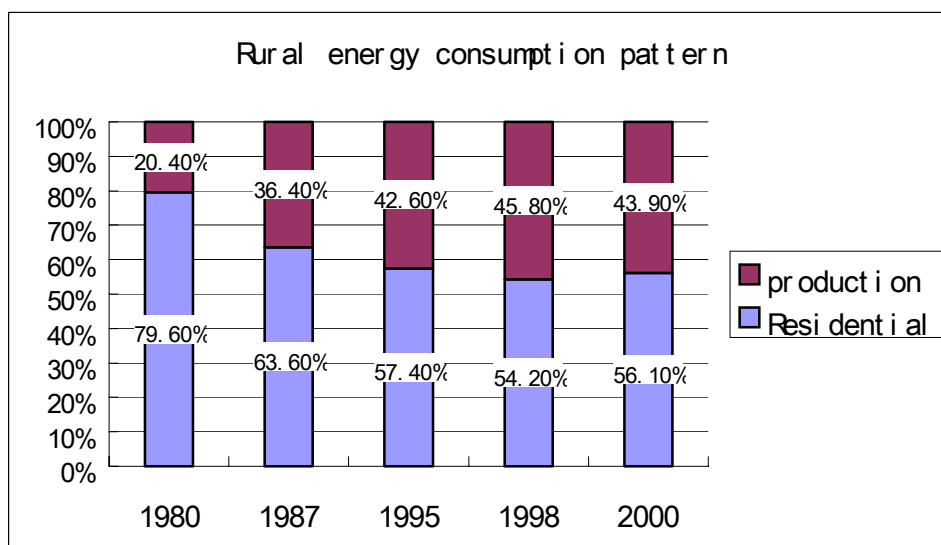
As can be seen from the figures of rural energy production, rural energy companies are small in size with respect to both the number of employees and fixed assets. In 2000, there are 2099 rural energy production enterprises. On average, each enterprise employs 18.3 people and has \$50,000 fixed assets. There are 3405 rural energy service companies with even smaller sizes, with 6.87 employees and fixed assets of \$14,000 on average (MOA, 2001, pp.300-303).

In summary, rural energy supply in China is characterised by self production from local sources rather than large scale energy companies. Coal and biological materials (straw, fuel wood and biogas) are the dominant sources for household cooking and heating. Small and micro hydro power also plays an important role in supplying electricity to rural households. Other forms of energy such as solar and wind power are in no way a serious source for rural household supply. This pattern of small scale local energy production has a series of negative social and environmental impacts. The supply of energy is insufficient and unstable, restricting the process of rural development and prosperity. Most of the fuels are highly polluting, damaging human health and the environment. Direct burning of straw and fuelwood as household fuels reduces the amount of crop residues for arable land and overharvest of forest, leading to soil and land degradation.

4 Rural Energy Consumption by Sector

There are two categories of energy users in rural areas: production and residential (figure 4). In 1980, nearly 4/5 of the total rural consumption of energy was for residential uses, indicating a low level of application of machinery in agricultural production and industrial activities. The share of production use is increased to over 1/3 in 1987, 2/5 in 1995 and close to a half of the total rural energy consumption in 1998. But still, residential consumption takes over 50% of the total energy in rural areas.

Figure 4 Rural energy consumption: production vs residential uses



There are a few interesting points to note. First, traditional non-commercial energy such as straw and fuelwood constitutes the major part of residential energy consumption. In 1980, 84.3% of the residential energy consumption was from non-commercial sources. This figure was reduced during the past two decades, but still it is as high as 56.7%. This pattern reflects the fact that energy used for production purposes is mainly from commercial sources. In 1980, only 13.4% of the total energy consumed in the production sector came from non-commercial fuel wood. The remaining was from coal, oil and electricity. In 1998, the share of biological fuel in total production use is reduced to 4.9%. Second, the absolute amount of non-commercial energy has been somewhat stable at around 250 million tce per year. This indicates that the major increase in rural energy consumption comes from commercial sources. As shown in table 4, the consumption of commercial energy increased from 99 mtce in 1980 to 408 mtce in 1998, 3 times higher. Third, the use of fuelwood has been on decreasing in both absolute and relative terms. The total amount of noncommercial energy was almost equally divided between fuelwood and straw in the 1980s. In the 1990s, however, the amount of fuelwood was substantially reduced in comparison to that of straw, with the former being 1/3 less than the latter. The reason for this change is largely attributable to the government policy for forestation and protection of forest for ecological rehabilitation.

Table 4 Rural energy consumption pattern, 1980-2000. mtce

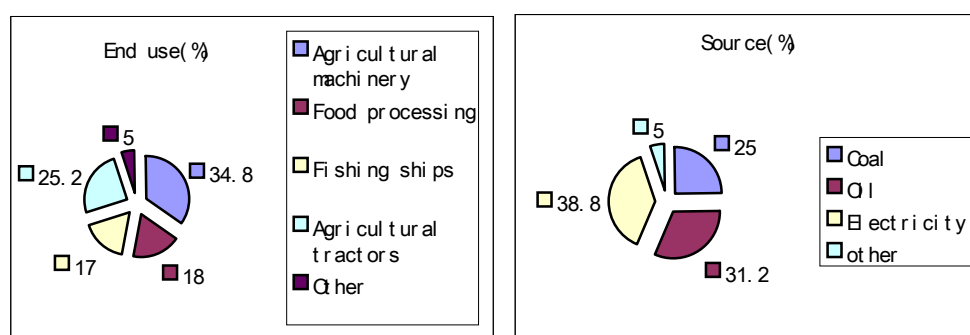
		Commercial energy				Non-commercial			total
		coal	oil	Electr.	Subtotal	wood	straw	Subtotal	
1980	Total	65.0	15.0	19.0	99.0	112.0	117.0	229.0	328.0
	Residential	37.0	1.0	3.0	41.0	103.0	117.0	220.0	261.0
	production	28.0	14.0	16.0	58.0	9.0	0.0	9.0	67.0
1987	Total	183.2	24.6	30.0	237.8	147.3	132.6	297.9	517.7
	Residential	59.6	1.9	5.0	66.5	103.0	132.6	262.9	329.4
	production	123.6	22.7	25.0	171.3	17.0	0.0	17.0	188.3
1995	Total	292.95	42.21	103.26	398.42	115.70	150.92	266.62	665.0
	Residential	86.11	2.56	41.97	130.64	100.13	150.92	251.05	381.7
	production	166.84	39.65	61.29	267.78	15.57	0.0	15.57	283.3
1998	Total	299.18	48.10	98.08	445.36	99.18	122.80	221.98	672.1
	Residential	116.70	6.45	29.81	152.96	84.01	122.80	206.81	364.6
	Production	182.48	41.65	68.27	292.40	15.17	0.0	15.17	307.6
2000	Total	282.81	56.09	68.67	407.57	99.18	124.23	223.41	630.32
	Residential	109.99	11.82	27.30	149.11	77.91	125.02	202.93	353.6
	Production	172.82	44.27	45.37	262.46	14.39	0.0	14.39	276.7

Note: rural production use of energy includes those for both agriculture and industry in rural areas. For rural residential, include 4.79mtce biogas.

Source: Zhou & Wang, 2002, p.366. MOA, 2001.

In the rural residential sector, coal and non-commercial fuels are mainly used for cooking and heating in winter. As to the use of limited amount of commercial energy, major end uses include lighting (diesel and electricity), electric appliances, and motor vehicles. In the production sector, fuel wood is mainly used for tea and food processing. Details of production of commercial energy use in 1995 are presented in figure 5. Agricultural machinery including tractors is the major consumer of rural commercial energy, accounting for 60% of the total end uses. Food processing and fishing fleet are also major end users. Overall, energy efficiency rate is low in agricultural use of commercial energy, being 29.5% as compared to over 40% in industrial and service sectors in 1995 (Zhou & Wang, 2001, p.368).

Figure 5 Agricultural production use of commercial energy, 1995



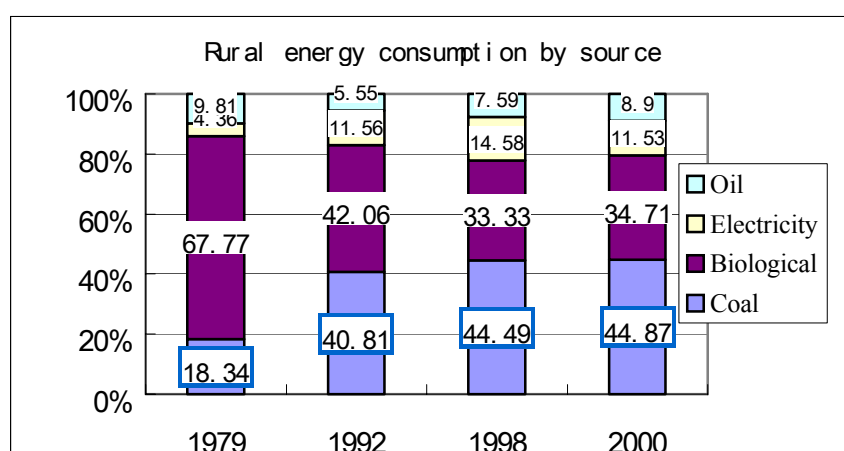
Note: the figures in the table are based on the end use of energy by the agricultural sector, excluding energy losses in the process from primary to end use.

Source: Zhou & Zhou, 1999, p. 124.

5 Rural Energy Consumption by Source

Coal and biological matters are the major sources of energy in rural areas, accounting for 80% or more of total rural energy consumption (figure 6). The relative importance of coal and biological matter in the energy mix has been reversed. In case of coal, share in the total energy consumption was increased from 18.3% in 1979 to 44.5% in 1998. The contrary case is for biological matters, with change of share from 67.8% down to 33.3% for the same period. The consumption of oil and electricity in the energy mix has also been on the increase, but the rate of growth for electricity is must faster, being over 10% for the period from 1979 to 1998. In terms of physical quantity of energy consumed, substantial increases can be observed for all the energy sources with the exception of biological matters.

Figure 6 Rural energy consumption by source 1979-2000, mtce



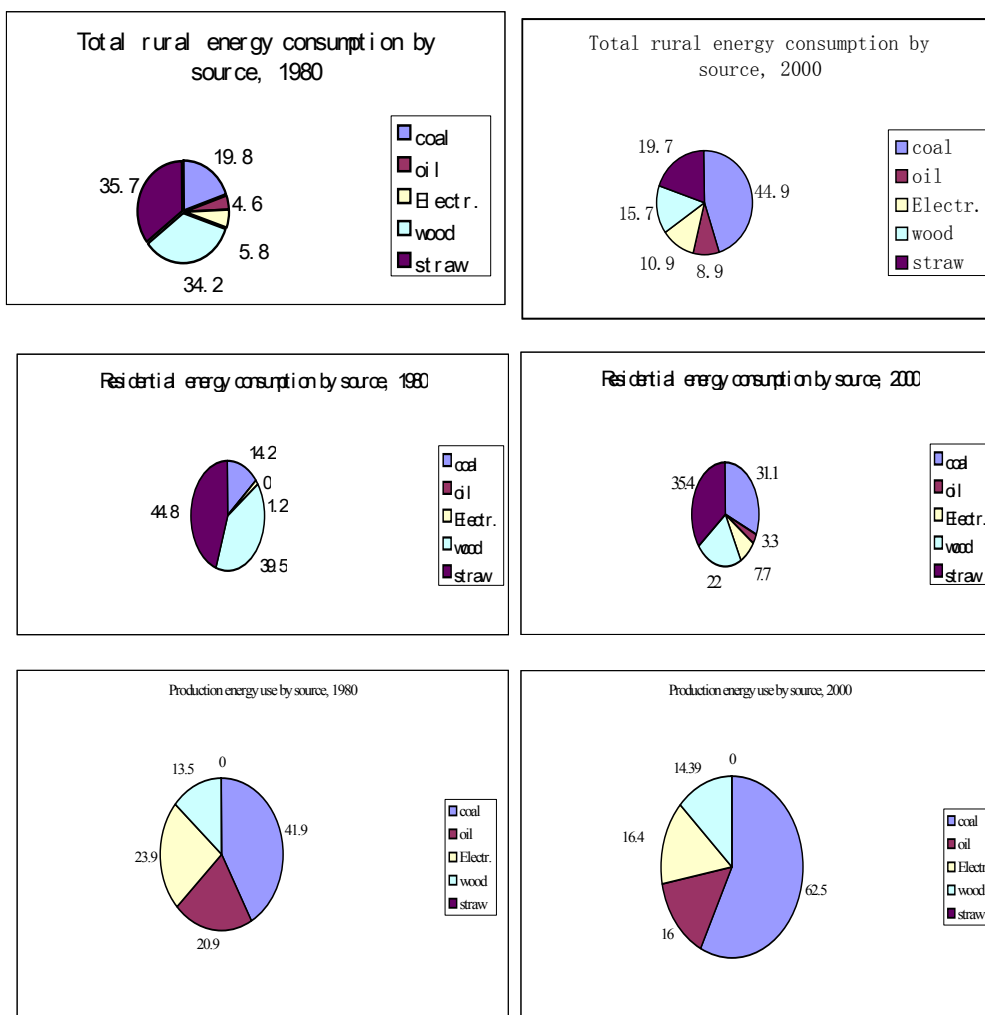
Source: CREA, 2000 (pp.7-8; p.53)

Figure 7 compares the sources of rural energy consumption in 1980 and 2000. In 1980, over 2/3 of the total is non-commercial traditional sources, with fuelwood and straw accounting for slightly higher than 1/3 each. High quality commercial energy consists of only 30% of the total in 1980, with coal about 20% and oil and electricity about 5% each. In 2000, non-commercial traditional biological matters account for only 1/3 of the total consumption. Commercial energy is still dominated by coal, but oil and electricity together are about 1/5 of the total consumption. It may be interesting to note that the share of non-commercial fuel wood for production use in rural areas was reduced from 13.5% in 1980 to 5.2% in 2000, but there is not much change in terms of physical quantity, being about 14 mtce. Use of both oil and electricity production in 2000 is proportionately less than that in 1980, but physical amount in 2000 is three times higher than that in 1980.

For residential consumption, crop residue takes nearly half of the total. As coal is mainly located in the North, rural residents in eastern and southern part of China in 1980 were almost confined to biological matters for cooking and heating. Oil and electricity were hardly accessible by rural households in 1980. This situation has been

significantly modified. 42% of the household energy consumption came from commercial sources in 2000. Electricity consumption is 6 times higher in 2000 than 20 years earlier.

Figure 7 Energy mix in rural China, 1980 and 2000, mtce



Evidently, oil and electricity are not for household cooking. Electric heaters and air conditioners are too luxurious for most rural households. Therefore, much of the increase in oil and electricity consumption is not used to replace household fuels for cooking and heating. The only source of major increase in household fuel must be from coal, which is 70mtce more in 2000 than that in 1979. The amount of biological matters replaced by coal does not seem to be very high. In 1979, there were 420 million rural people in shortage of cooking fuels (3-6 months). This figure was reduced to 70 million in 1998. Overharvest of fuelwood was reduced from 90 million tons to 30 million tons. The share of biological matters in rural residential energy consumption is still as high as 57.4% in 2000, though much lower than the figure in 1980 (84.3%). Considering population growth over the period, the actual increase in per capita rural household fuel consumption is minimal.

There are a few reasons why there is not much increase in rural household fuel consumption. One is due to the “energy saving/efficient stove/heating program” in rural China. In 1998, 185m households (about 80% of total) used energy efficient stove/heating, with energy efficiency being over 20%. This program saved some 90mt (50mtce) of crop residue and fuelwood. A second reason is attributed to urbanisation over the period. The share of rural population over national total has been consistently reduced from 80.61% in 1980 to 63.8% in 2000. However, there has been a slight increase in the absolute numbers of rural population from 790.5m in 1980 to 807.4m in 2000 due to population increase. A third reason is the level of production of bioenergy sources cannot be expanded without substantial increase in arable and fuelwood land. Restriction of overharvest of wood and other uses of straw direct rural households to use other forms energy.

6 Regional Variations

There are four significant variations in energy consumption in China: urban-rural, east-west, rich-poor and topographical and climatic.

6.1 Rural-urban divide

There has been a huge gap in energy consumption between urban and rural households since late 1950s when the household registration system officially restricted the movement from rural to urban areas where the living standard is much higher than that in rural regions. This rural-urban divide is well observable in energy consumption as discussed earlier. Rural residents largely depend on non-commercial biological matters as household fuel while urban residents exclusively use commercial energy. Nevertheless, rural residents, especially those close to cities, also have limited access to commercial energy but their share is only a small fraction. Table 5 presents a detailed comparison of commercial energy consumption between rural and urban residents.

Table 5 Household consumption of commercial energy, 1995

	Total %		Per capita kgce		Urban/ rural
	urban	rural	urban	rural	
Total cons	66.73	58.70	236.3	65.1	3.63
By source					
Coal	59	87	139.4	56.4	2.47
electricity	12	9	28.4	5.9	4.81
Oil, gas, etc	29	4	68.5	2.8	24.5
End use by source					
Heating	38.0	28.0			
cooking	50.0	68.0			
Lighting, elect. appliances	12.0	5.0			
Enduse effic	45.0	25.0			

Note: population numbers used in the calculation is taken from MOA (2001), which is based on household registration as given by Public Security Offices.

Source: Zhou & Zhou, 1999, p.129, MOA, 2001.

In 1995, urban population consumed 10% more of commercial energy than their rural counterparts. This is highly unproportional to their share of population, with one urban three rural. This suggests that each urban Chinese used 3.63 units of commercial energy as compared to one unit by an average rural Chinese. The gap is even bigger in electricity consumption. The consumption of electricity by residents on average is only 1/5 of the urban people. Electricity use in the rural households is mainly for lighting as there are very limited electric appliances in rural households ((figure 8 and table 6). For instance, nearly one in three households in urban areas has bought an air conditioner while in the rural areas, about 1 out of one hundred. Due to large requirement for investment, gas pipelines are hardly extended to rural regions. The biggest difference is in the consumption of natural gas and oil products, being 24.5:1.

Figure 8 Change of per capita income, rural vs urban residents

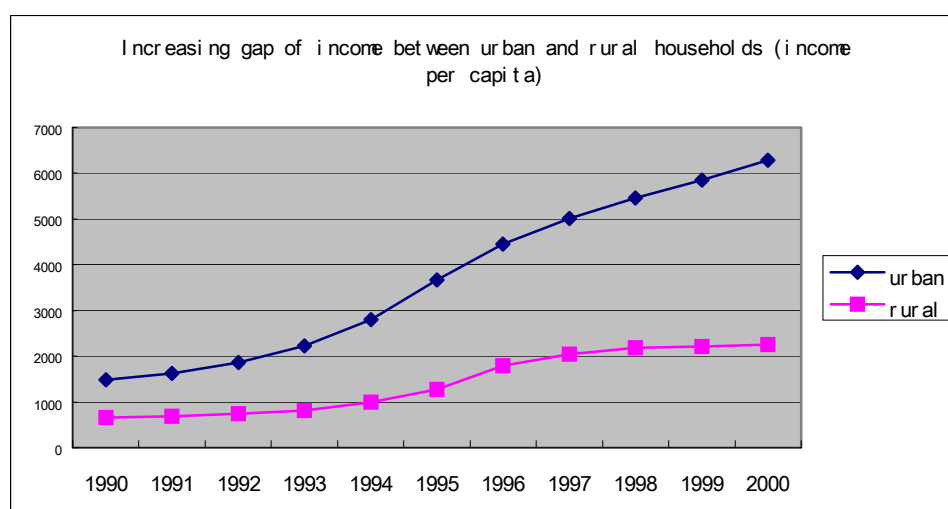


Table 6 Increasing gap of income between urban and rural households (income per capita)

	Washing machine		refrigerator		Colour TV		Air conditioner	
	urban	rural	urban	rural	urban	rural	urban	rural
1990	78.41	9.12	42.33	1.22	61.40	4.72	0.34	0.00
1993	86.36	13.92	56.68	3.61	79.46	10.92	2.23	0.05
1995	88.97	16.81	66.22	5.15	89.79	16.92	8.09	0.18
1996	90.09	20.54	69.67	7.27	93.50	22.91	11.61	0.29
1997	89.12	21.87	72.98	8.49	100.48	27.32	16.29	0.38
1998	90.57	22.81	76.08	9.25	105.43	32.59	20.01	0.58
1999	91.44	24.32	77.74	10.64	111.57	38.24	24.48	0.74
2000	90.5	28.58	80.1	12.3	116.6	48.74	30.8	1.32

Source: Yao et al, 2002, p.20; CSB-RS, 2001.

If we look at the end uses between rural and urban households, we may find that over 2/3 of the rural household commercial energy goes to cooking while the urban household spends only half of total households commercial energy. With respect to enduse energy efficiency, the rate for rural areas is only 25% though this rate is after the successful campaign of energy saving stoves in rural regions. In the urban case, the rate is 45%, almost twice as high.

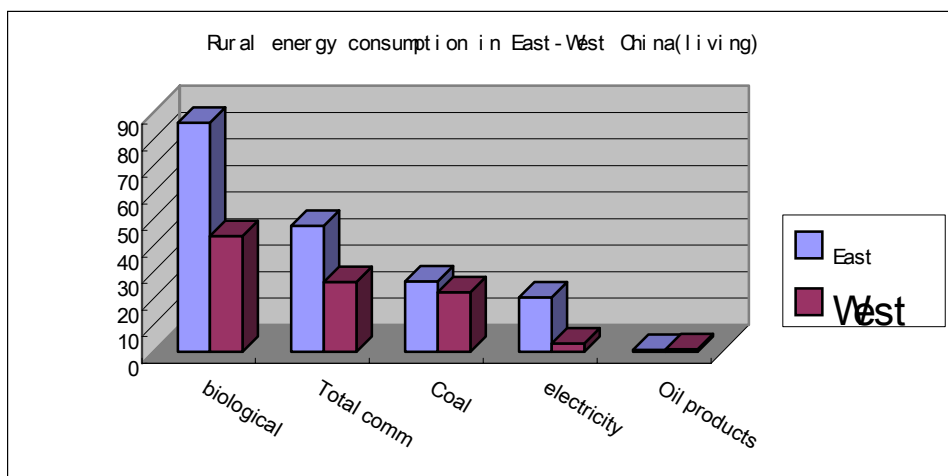
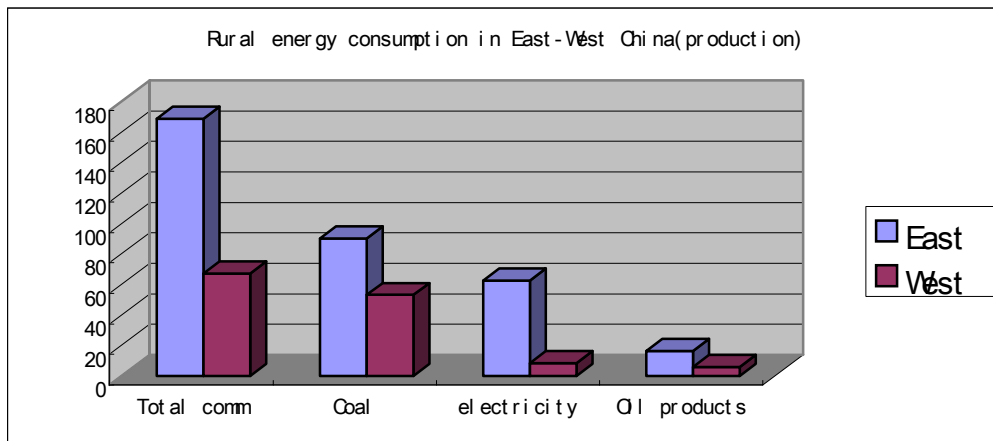
In 2000, total energy consumption including non-commercial sources reached 1.5 billion tce (12.8 commercial and 2.2 noncommercial). Average in China is therefore 1.18tce. per capita energy consumption is 0.77 tce while that in urban areas is 2.58 tce⁸.

6.2 East-west divide

Since the start of economic reform in the late 1970s, the gap between east and west has been enlarging. From figure 9, we may note a few interesting points. First, for all the regions in the production sector, coal is the dominant source of energy but electricity and oil products take a much higher share in the energy mix in the East than that in the west, being 46.6% and 20.8% in 1995 respectively. In the residential sector, the difference becomes larger: being 44.3% in the East and 14.9% in the west. Second, the more developed East consumes more energy than the less developed West. The population in the East is only 50% more than that in the West, but commercial energy used for production in the East is 152% more. Even in residential use of commercial energy, rural households in the East uses 80% more commercial energy than those in the west. Third, biological matters constitute a big share in the energy mix of rural residential energy consumption, but non-commercial energy in the east accounts much less in their total energy consumption, being 64.5% as compared to 76.8% in the west.

⁸ using the CSB data on rural population, the number is 1.89 tce.

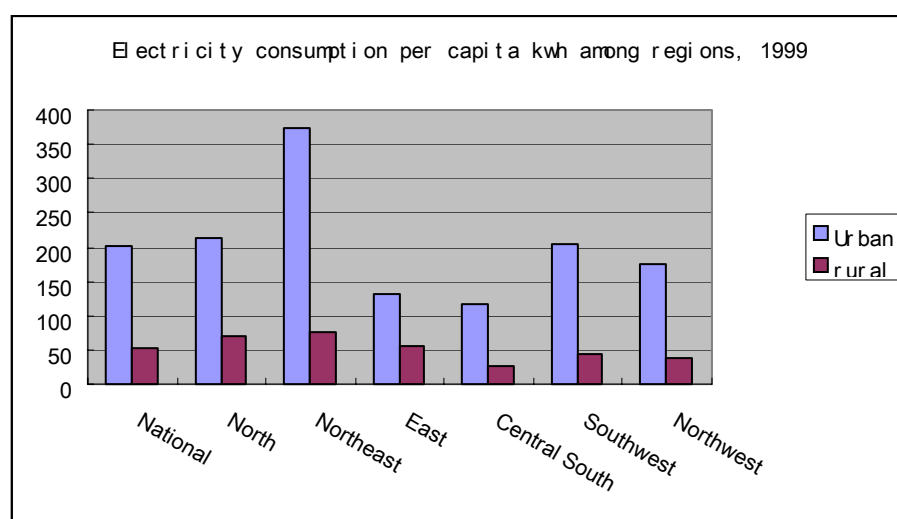
Figure 9 Rural energy consumption in East-West China, 1995mtce



ote: east: Beijing, Tianjing, Shanghai, Liaoning, Hebei, Shandong, Jiangshu, Zhejiang, Fujian, Guangdong. Total rural population: 309m; West: Yunnan, Guizhou, Sichuan, Shaanxi, Ganshu, Ningxia. Rural population: 206.3m. Source: CAREI, 2000, p.8.

Figure 10 shows the variations of per capita electricity consumption among regions. For all the regions, urban residents use more electricity than their rural counterparts, but in the more advanced region the gap is much smaller than that in the less developed western part. In the eastern region, the ratio of urban over rural per capita electricity consumption is 2.4 as compared to close to 5 in the western region. In addition, the differences in electricity consumption by rural residents are large among regions. The figure in the central and south region is only about half of the national average while that in the old industrial northeast region is almost 50% higher than the national average.

Figure 10 Electricity consumption per capita kwh among regions, 1999



Rural household expenditure on energy follows a similar pattern (table 7). In the more advanced Shanghai and Zhejiang, rural residents spend more money on cleaner forms of energy such as electricity and gas while in the less developed areas more money is spent on dirtier raw coal and traditional biological matters. As income level is higher in rich regions, the share of expenditure on energy consumption over total household expenditure is lower, being less than 3% in Shanghai and Zhejiang.

Table 7 Expenditure on energy consumption by households in selected rural regions, 1996 (y/c.a)

	China	Shanghai	Zhejiang	Shandong	Sichuan
electricity	17.7	49.43	31.67	18.73	13.2
coal	11.79	0.01	0.25	17.18	8.47
coal prod	4.39	0.18	3.98	9.28	0.38
fuelwood	30.64	10.04	15.94	52.91	27.26
charcoal	0.43	0	0.13	0.17	0.22
other	5.92	28.96	19.95	13.6	1.46
total	70.87	88.62	71.92	111.87	50.99
total expen	1590.7	4206.9	2890.7	1595	1440.8
%over exp	4.46	2.11	2.49	7.01	3.53

6.3 Rural poor-rich divide

With the collapse of rural communes and relax of mobility restrictions in rural areas, the gap of rural household income has been enlarging (CSB-RS, 2001, pp. 57-62). In 1980, the income of the richest 1.62% of rural households is 8 times that of the poorest 5.6%. In 2000, the richest 7.45% rural households earned 7394.6 RMB per capita⁹ while poorest 8.45% rural households received 539.2RMB per capita¹⁰, some

⁹ Net income (gross minus expenditure). Note here all the self produced and consumed items such as straw and water are converted to income in the calculation. Net income is close to cash income which is liquid and expendable.

¹⁰ Author's calculation based on rural survey data. The official poverty line for China was set at 625 RMB per

13 times difference.

In the official statistics, expenditure on energy consumption is included in the category of housing and related residential items. Water, lighting and fuels are included in “related costs”. In 2000, the poorest 10% rural households spent 211 RMB on related cost while the richest 10% 430 RMB (CSB, 2001, 307-307). In many rural areas, the price for electricity was between 1.0RMB to over 5 RMB per kwh. As straw and fuelwood consumption was monetised in the statistics, it can be inferred that the poor households were unable to afford commercial energy if they did have access.

6.4 Geographic/climatic variations

With land area of 9.6 million km², there are different climatic zones from east to west and south to north. In Manzhouli, the northern tip in Heilongjiang province, mean temperature in January (the coldest month) is -23.6°C as compared to 15.7°C in Hongkong¹¹. Table 8 present survey data on three villages in northern (Heilongjiang (East most) and Xinjiang (west most) and southern China (Jiangshu).

Heping village in Helongjiang Province is engaged primarily in intensive agricultural production. Agricultural machinery used most of the oil products and electricity. Because of cold temperature in winter, residential heating consumed over 1/3 of the total commercial energy. For household cooking, crop residues were the major source of energy. However, due to its cold temperature, no biogas is produced for the villagers. Taking all forms of energy together, per capita consumption amounted close to 1 tce in 1999. Village C in Jiangshu Province is located in the more industrialised and warmer southern part of China. Only about a quarter of the total energy consumption is for residential purposes. The biggest share of commercial energy is electricity (close to 3/5), indicating a high level of electric appliances ownership. Agricultural production is still a major activity and crop residues are part of the residential energy, accounting for over 70% of the total. Warm climate at around 16°C makes the use of biogas viable though the share is still very small. Village D in Xinjiang is located in a very remote part of the province with no access to electricity. Cropping is not practiced in this village and fuelwood is the major source of biological form of energy. Due to long and cold weather, per capita energy consumption is the highest among the three villages surveyed though income is the lowest.

capita per year and the official number of people below poverty line is 3.4% (CSB-RS, 2001, p.38) in 2000. Clearly the numbers do not seem to be consistent with the household survey data as given in pp. 57-59.

¹¹ Zhang Jiacheng (ed), 1995. Natural Resources in China: Climate. P. 104

Table 8 Energy consumption surveys in three villages, 1999

Village name	Heping	Village C	Village D
Location	Heilongjiang Suihua	Jiangshu Jinhu	Xinjiang Qinghe
Survey year	1999	1997	1998
Population	4080	5277	496
Households	1160	1505	80
Income(y/c)	2600	3269	1925
Per capita Energy cons. tce	0.97	0.32 (1.16 incl industry)	1.15
Crop residue tce	2463.32	1230.6	
Fuelwood tce		76.3	210.13
biogas		3.2	
Coal tce	1076.71 (35.4)	112.3	360.42
Elec. Tce	35.67 (14.8)	206.2	
Oil tce	299.40 (43.6%)	2.8	1.58
LPG	71.41 (6.2%)	37.2	
total	3946.51 (100%)	1668.6	572.13
Total expenditure(y/c)	313.16		117.9
Agricultural prod use (tce)		591.6	
Industrial use		3842.8	
Total (residential +production)	3946.51	6103	572.13

7 Major reasons behind the patterns

Rural energy production and consumption in China is characterised by low per capita level and high proportion of non-commercial biological matters. In this section, we look at the reasons behind the patterns.

7.1 Supply/demand

To a large extent, the pattern of energy production and consumption is shaped by supply and demand in rural regions. Biological matters are available and almost free as a by-product in rural areas. As a result the amount of crop residue is determined by agricultural production and thereby availability of arable land and water resources. In China, arable land is only 0.08ha per capita, less than 1/3 of world average. Shortage of water amounts 500 billion m³ water for agriculture. There is no water for irrigation for 20 million ha dryland and 80 million rural people are in shortage of drinking water (CAREI, 2000, P.3). The same is true for fuelwood production (p. 57). The sustainable harvest yield level in China is 158mt in 1998, still 18mt over harvest of fuelwood after decades of efforts to curb natural degradation.

Comparative costs of fuels are very important factors in the choice of fuel. Table 9 compares the cost of collection of crop residue as fuel. It is interesting to note that the cost is very close for collection of crop residue. As labour cost is high in Zhejiang, rural residents collect crop residue within a radius of 2 km only. In the less developed inland Sichuan province, labour cost is low and rural residents go much farther away to collect biological matters as household fuel.

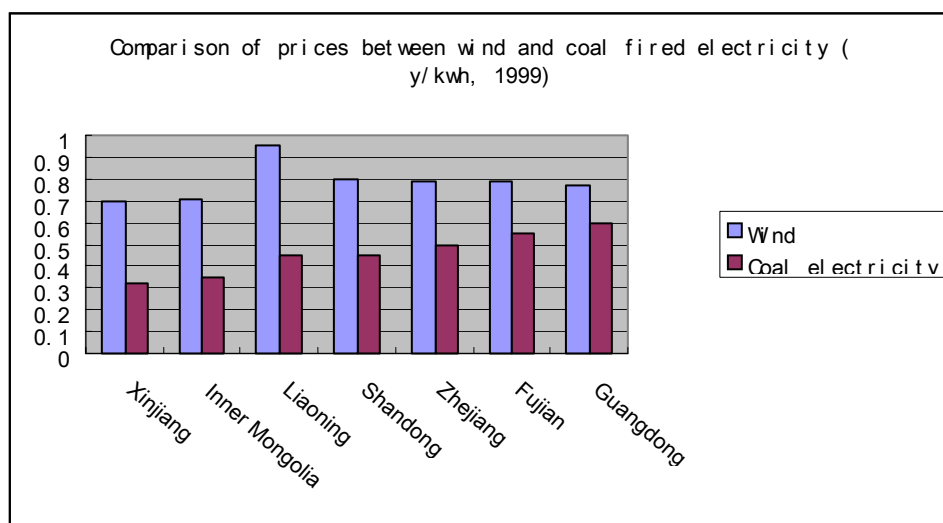
Table 9 Economics of collecting crop residue

	Zhejiang	Shandong	Sichuan
% of crop residue as fuel	23.3	34	41.2
Radius for collection	2km	3km	Up to 8 km
Collecting cost per kg	0.14-0.2	0.12-0.2	0.15-0.2
Per capita income for rural residents	4253.7	2659.2	1892.4

Source: CAREI, 2000, p.26; CSB-RS, 2001.

New and renewable energy development has been promoted in rural areas for almost two decades, but the application does not seem to be satisfactory. As shown in table 6, all the new and renewable energy putting together constitutes a very small proportion of total energy production and consumption in rural China. This is simply due to the high cost of production. For instance, herdsman household using 100w wind turbine spend 2.31 RMB yuan per kwh, 4 times higher than the price of electricity for urban residents (Gu et al, 2001, p. 163). Due to scale of economy, wind farm is more cost-effective. A windmill in Huitengxile, Inner Mongolia installed 33 wind turbine with each 600kw capacity. The cost per kwh is 0.620yuan. The wholesale price to power grid is 0.713 yuan, but coal fired thermal power is only 0.32y/kwh. The differences in costs of electricity supply are given in figure 11.

Figure 11 Comparison of prices between wind and coal fired electricity (supply price to power grid, y/kwh, 1999)



Source: Zhou and Wang, 2002, p. 446.

Perhaps the most restricting factor for low level of commercial energy consumption may lie in low level of income. In 1985, the ratio of dispensable income per urban resident over that of rural one is 1.86. This gap is enlarged to 2.20 in 1990 and 2.71 in 1995. In 2000, it is further increased to 2.79 (CSB, 2001, p. 303). Low purchasing power restricts the level of consumption of commercial energy. The east-west and rich-poor divide in commercial energy consumption is rooted in income differences.

7.1 Government policies and Institutions

Since the early 1950s, China has followed a route of industrialisation and to a lesser extent urbanisation. Under planning system, investment in energy development was under strict control by the state sector and supply of commercial energy to rural regions was not on the agenda. With market reform after the middle of 1980s, investment has been more diverse but commercial energy use in rural areas has yet to be included in the main stream due to large capital investment and low return from investment. Under the planning system, capital accumulation for development of commercial energy and industrialisation was partly by unequal exchange of products between agricultural and industrial sectors. Government attention to rural energy issues was due mainly to food security and degradation of natural environment rather than the need for increase in living standard.

In the 1950s and 1960s, serious shortage of rural household fuels led to reduced supply of straws for livestock foodstuff, organic fertiliser and raw materials for industrial products. At that time, government policy was directed at local supply without any consideration of commercial energy development (Zhou and Wang, pp.368-373). The government focused on three areas of rural energy development: biogas, small hydro and small coal mines. In 1950 and 1959, Mao Zedong¹² twice instructed development and promotion of biogas. In 1979, 5 million RMB was provided to subsidize biogas; in 1984, the General Office of the State Council endorsed a report by the Ministry of Agriculture to further promote biogas development.

Even so, the degree of government restriction on commercial development in rural regions drove the up and downs of the production and use of high quality energy. This is exemplified in the locus of non-state sector coal production. In 1957, Zhou Enlai¹³ issued a government directory for small coal mine development in rural areas to replace fuelwood and straw for the benefit of soil and water conservation, straw back to field, and forest regeneration. Production of coal by small coal mines increased from 6.49mt in 1957 to 21.95mt in 1960. In 1965, output reached 95.32 mt. In 1984, State Council issues 8 new measures to encourage rural small coal mines. As a result, output reached 273.18mt. In 1993, State Council decided to liberalise price control on coal. Immediately, production increased from 425.48mt in 1992 to 554.90 in 1994. In 1996, the peak yield level was 614.77mt, 44.7% of national total. Since 1997, the government commanded to close small coal mines. And by 1999, total output was reduced to 317.00 mt, 30.4% of national total. By May 2000, 33,220 small coal mines were closed. Total number of small coal mines was reduced from 70,000 in 1998 to 38,000 in 1999.

However, there are two serious government initiatives for increase in rural access to commercial energy, in particular, electricity. In 1982, Ministry of Water and

¹² The paramount leader in China as the Chairman of the Communist Party until his death in 1976.

¹³ The premier in China from 1949 until his death in 1976.

Electricity (MWE) started planning of a scheme of *100 rural hydro counties* and received endorsement of the State Council in 1984. In 1982, another 100 counties were selected to demonstrate rural electrification and 100 million RMB loan was provided for this scheme. By 1995, another counties succeeded in rural electrification with hydro development. By 1997, a total of 318 counties were completed hydro electrification. The other initiative is the scheme of *rural electricity network upgrading*. In 1998, State Council decided to improve rural power supply system so as to unify power system and price between urban and rural areas. A total amount of 180 billion RMB from treasury bond was allocated. As a result, power loss in transmission decreased from 25% to lower than 12%. Price of electricity was more than halved though still higher than the prices for urban residents. This has led to a saving of expenditure on electricity in rural areas at 30 billion RMB a year¹⁴.

Still does discrimination exist. On 4th September 2002, SDPC (State Development and Planning Commission) formally approved the proposal of electricity pricing in Hainan Province. For the first time, rural residents in Hainan Province will enjoy the same price for electricity consumption as their urban counterparts. However, industrial users in rural areas have to pay 0.69 RMB per kwh while for similar users located in urban areas, the price is 0.594¹⁵. Even for agricultural users, the price is 0.64 RMB yuan per kwh in rural regions but 0.469 if they are located with the boundary of cities.

7.3 Improvement in energy efficiency

In rural China there is a serious lack of energy but at the same time energy use is very inefficient. Therefore, the government has been very successful in the promotion of energy saving/efficient cooking stoves. In 1980, residential burning of bioenergy was 229mtce and 37mtce coal, with heat efficiency at only 10% or so, even coal stove at about 18% efficiency. In 1983, General Office of the State Council endorsed and circulated the report on acceleration of rural energy saving stoves prepared jointly by State Planning Commission and Ministry of Agriculture, starting large scale campaign to replace the old inefficient to new and efficient stove. Heating efficiency with the new stove is about 25-30% and coal stove 30-40%, more than twice of the old stove. On average, energy saving is between 50-50%. By 1999, a total of 189m rural households applied the new stove, accounting for 80% of the total rural households.

7.4 Environmental and ecological considerations

Because of overharvest of fuelwood, water and soil erosion has been silting the rivers and reservoirs, causing serious damages. Land degradation and ecological imbalance are also related to over use of biological fuels. After the middle of 1990s when food shortage tended to be off the agenda, the government has pursued an aggressive policy of natural rehabilitation by retreating arable production from low quality land.

¹⁴ People's Daily, page 1, 12 October 2002.

¹⁵ Voltage below 1kv. For voltage above 1kv, the price for urban industry is 0.589 and that for rural 0.65.

8 Assessment of Data Sources

Chinese official statistics has often been questioned due to political interference with the generation of statistical data. But this is the major source of data. Also some technical parameters seem to be different by sources. This section gives an overall assessment on the data sources for analysis.

8.1 Statistical data

The official government agency China Statistical Bureau is designated to collect and produce official data on a comprehensive and annual basis. Many ministries and provincial level statistical bureaus also publish sectoral and provincial statistics. Relevant statistical year books include:

- China Statistical Yearbook, published annually. Only commercial energy is included in the tables for the nation as a whole. There is no data on use of non-commercial energy. No separation of rural-urban consumption but there contains data on sectoral uses of commercial energy. For residential consumption, household fuels and electricity are included in the category of residential living in monetary terms with no physical amount available. However, this is the most comprehensive and officially authoritative set of statistics for general uses.
- Yearbook of China Rural Households Survey. Each year, the CSB Survey Team for Rural Socio-Economic Status samples 67,000 rural households all over the country to gather data on rural production, income, expenditure and related items. In the yearbook, some time series data is also provided. Most useful information is on households income and expenditure by income groups and by provinces. Again, there is a separate item on household energy consumption which is included in the category of residential living.
- China Energy Statistical Yearbook: compiled by the CSB-IT (Department of Industrial and Transportation Statistics). This is not an annual publication, with the latest published in 2001 covering data between 1997 and 1999 and the first in 1986. It provides more details on energy consumption by sector, by source and by provinces than the overall comprehensive yearbook. In this edition, there are three tables documenting consumption of three non-commercial energy sources (biogas, fuelwood and straw) for rural households by provinces. Nevertheless, the sources are not collected by CSB-IT but taken from the Ministry of Agriculture. In earlier editions, no such information is available.
- China Agricultural Statistic Data, compiled by the Ministry of Agriculture. This publication contains the most detailed records of rural energy consumption by source, by sector and by provinces though incomplete. Information on investment and rural energy enterprises is also available.
- China Energy Report: provides overviews on energy production and consumption but with limited statistical information, in particular on rural non-commercial energy.
- China Rural Energy Yearbook. This is not an annual publication. It contains

more details but much of the useful information is already in China Agricultural Statistic Data, which is updated on an annual basis. However, some of the analysis can be of great reference although the focus is on non-commercial energy resources.

The statistical data are in general consistent but in many cases incomplete and require verification. Cautions must be taken in using and interpreting these data.

8.2 Technical data

For non-commercial energy consumption, there is no statistics but information is obtained by estimates using some technical conversion factors (table 10). For instance, production of crop residue is associated with production of agricultural yields and then converted to coal equivalent for comparison. Uncertainty may arise from several factors.

- Ratio of crop residue: different sources appear to use different ratios. The category of other crops may cover too many for accuracy.
- Conversion factor to coal equivalent: there are also differences.
- Conversion factors of other forms of energy into coal equivalent

Table 10 Estimation of crop residues: conversion factors

crop	residue/grain		coal equivalent index	
	CAREI, p. 40	Gu et al, p.2	CAREI, p.	Gu et al, p.
rice	0.623	1	0.429	0.429
wheat	1.366	1	0.5	0.5
corn	2	2	0.529	0.529
other grain	1	1	0.486	0.529
beans	1.5	1.5	0.543	0.486
root crops	0.5	1	0.486	0.486
oilseeds	2	2	0.529	0.441

Due to the lack of statistics, consumption of non-commercial energy by rural households cannot be as accurate as that of commercial sources of energy.

A further difficulty of data lies in the separation of rural-nonrural residents. CSB survey data is different from sources by the Public Security Offices. In rural regions, the rich-poor divide in energy consumption is unavailable.

8.3 Research papers, journals and unpublished materials

Rural energy issues in general are not the key topics but are included in many of the publications. Limited information is also available on the internet. Information from this set of sources is rather fragmented and requires careful assessment.

9 Conclusions and Suggestions

9.1 *Tentative conclusions*

Given the preliminary assessment on rural energy patterns in China, we are able to gain some overall understandings on rural energy consumption in China and the quality of data.

Rural China is of significance in terms of its size of labour force (479.63million)and population (800million) and to a lesser extent output (16% of GDP). With respect to consumption of commercial energy, the rate per capita in the rural households is only a fraction of his urban counterparts. Agricultural production uses less than 5% of total commercial energy. Coal is the dominant form of commercial energy although its share has been on the decrease. The share of non-commercial energy over the total by rural residents has reduced substantially from 4/5 to about 1/3, but biological matters still constitute a major source of household energy for cooking and heating. The total amount of crop residue is about 600 million tce with 1/3 used by rural residents as fuels. Fuelwood has been overharvested for long but there is a total of some 90 million tce for sustainable use as energy sources. Biogas, wind and other forms of renewable energy are in use in rural China but take a very small share of the total consumption.

There are significant variations in rural energy consumption. Four divides are in existence: urban-rural, east-west, rich-poor and geographic/climatic. The reasons behind the variations are attributable to a number of reasons, but mainly to policy discrimination, low income and high cost of commercial energy, improvement in energy efficiency and environmental considerations.

Information on rural energy consumption is rather scattered and there is certain degree of inconsistency among the sources. In general, an overall picture can be drawn with available data, but specification and verification is required as existing data do not seem to meet the need for in-depth analysis.

9.2 *Key areas for further study*

The above conclusions may be of help for an overall understanding of energy patterns in rural China. But it is preliminary, incomplete and requires further work for a better understanding of the picture. Based on the preliminary assessment of data sources, the following issues have been identified for further investigation:

- Data: As future increase in consumption of commercial energy will be mainly from the shift of rural to urban population, it is important that reliable data be made available for analysis and policy making.
 - Actual consumption of commercial energy by households;
 - Production and consumption of non-commercial new and renewable energy resources at households and village level
 - Industrial consumption of commercial energy: agricultural input and rural

industrialisation/urbanisation

- Transition process from traditional to commercial energy: by further examination of the 4 divides identified in this paper and their implications for energy consumption, to gain when, where, how, how fast and why the transition takes place in rural areas;
- Energy consumption in the context of sustainable development in rural China: social, economic and environmental perspectives; future demand for and constraints on energy consumption in rural areas to meet the goals of sustainable development.
- Methods:
 - Sample survey at household level in typical villages is a must for interpreting and using the official statistical sources;
 - Consistency of methods: Different sources give inconsistent methods and numbers. They need to be made consistent before used for analysis.
 - Modeling exercises: bottom-up approach may be preferred at this stage of analysis.
 - International comparisons.

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