

Energy Consumption in Rural China: Analysis of Rural Living Energy in Beijing

Yu Yang^{1,2}, Liu Yifang^{1,2,3} and Zhu Wei¹

1 School of Economics, Central University of Finance and Economics, Beijing 100081, PR China

2 Green Economy and Regional Transformation Research Institute, Central University of Finance and Economics, Beijing 100081, PR China

3 Corresponding author. Tel:+86 13810249357.E-mail address: liuyifang08@163.com.

Abstract. Under the pressure of climate change and international carbon reduction targets, long-neglected rural energy consumption needs to be given high priority. China's rural energy consumption structure is in the transition from non-commercial to commercial sources, and rural energy has become a key determinant to slow down the carbon emission growth. This paper systematically calibrates the current situation of rural energy consumption in Beijing by using the survey data of 1866 households in 13 districts and counties in Beijing based on the trend of energy supply and demand change in China. To this end, the paper combines rural policy measures to assess the pressure on coal-burning and clean energy supply trends, puts forward the rural energy structure adjustment path, with a view to promoting the use of clean energy in rural areas and reduce the environmental consequences of coal-burning .

1. Introduction

China's energy consumption in 1916 was 3.48 billion tons of coal equivalent, of which coal consumption accounted for 68.4% of the country's energy consumption, and 49.4% of the world's energy consumption. With the improvement of industrial energy efficiency and the government's management and regulation of high energy consumption and high pollution industries, global energy demand and carbon growth are now mainly derived from household energy consumption^[1]. Since Open Door Policy, along with the rapid development of China's rural economy, rural energy consumption demand increased significantly, and the energy consumption structure is in the transition from non-commercial to commercial sources. From aspect of the per capita use of energy consumption, rural residents' living energy consumption has witnessed a substantial increase from 88kgce in 2000 to 311kgce in 2013, while urban residents' from 213kgce to 357kgce, with an increase of only 67%. From the structural aspect, rural traditional biomass energy consumption fell from 71% in 1979 to 34% in 2005, and commercial energy consumption increased from 17% to 44%, mainly coal^[2]. Coal has always been considered as main factors to accelerate the pace of environmental pollution. In fact, China's carbon dioxide(CO₂), sulfur dioxide(SO₂), nitrogen oxide and particle emissions are mainly derived from coal and rural renewable energy consumption^[3].

Rural energy refers to the energy supply and consumption in rural area, is the the necessary energy source for development of rural production, improve the lives of people. The energy consumed in rural areas is divided into two parts: production energy and living energy. Living energy is mainly used for cooking, lighting, heating and household appliances.

The research content of this paper is the rural living energy (not including fuel), does not involve



rural production energy.

Rural energy is an important part of the energy system. According to “Beijing Statistical Yearbook 2016”, rural living coal consumption in 2015 is 1,718,100 tons, accounting for the city's total coal consumption (11.5357 million tons) of 14.89%. The combustion of poor quality coal in rural areas has caused serious pollution.

With the rapid development of rural economic and urbanization, it's urgent to make shift on the high-ratio of coal consumption and unbalanced energy structure. To this end, the paper conducted a survey on the typical energy consumption of farmers in 13 districts and counties in Beijing in 2014-2015, with a view to investigating the status quo, consumption behavior and energy policy effect of rural households in Beijing under urbanization.

The structure of the paper is as follows. The survey sampling methods are described in Section 2. Section 3 mainly discusses the situation and characteristics of rural living energy in Beijing. Section 4 concludes and puts forward countermeasures.

2. Investigation on Rural Energy Consumption in Beijing

This data is based on the survey of rural energy consumption conducted in October 2014 and January 2015. Investigations were carried out in 13 agricultural counties with the exception of Dongcheng, Xicheng, Shijingshan districts of Beijing. The survey selected 214 villages from the 3938 administrative villages, accounting for 5.4% of the total number of villages, which is statistically representative. A total of 1866 households were surveyed, 1866 valid questionnaires were collected as a result of the full use of home field survey.

The sample statistics follow such characteristics. From the aspect of household income distribution, the annual income of all households were divided into 6 grades: 5,000 yuan accounted for 5.2%, 0.5-1 million accounted for 9%, 1-2 million accounted for 19%, 2-4 million accounted for 26.8%, 4-6 million Yuan accounted for 21%, more than 60,000 yuan accounted for 19%. From the aspect of family income sources, 53.8% of the total number of households with foreign labor service as the main source of income, followed by planting, accounting for 29.3%, 10.6% of households lived on real estate rental, a lower proportion of 6.3% mainly depended on commercial operation and aquaculture.

3. The analysis and characteristics of rural living energy in Beijing

3.1. Energy consumption structure of farmers

Using the combination of input energy and local energy, consuming varieties of complementary energy is the main feature of rural residents' energy consumption, which is different from urban residents who mainly depend on commercial energy, such as electricity, natural gas.etc. Among the surveyed households, the number of users in electricity, coal, liquefied gas ranked the top three, accounting for the proportion of the total sample as 100%, 71.8% and 73.4%, solar water heater users accounted for 41.6%, the proportion of fuelwood users was 37.4%.

3.2. Per capita energy consumption and costs

The average consumption of coal, electricity, fuelwood, liquefied petroleum gas and natural gas of all sample households and energy consumption households can be seen in Table 1. The per households consumption was 3.04 tons of coal equivalent and per capita energy consumption was 1.0 tons of coal equivalent.

Table 1. Household per capita energy consumption.

Energy sources	All sample households ^a			Energy consumption households ^b	
	Per households consumption (physical unit)	Per households consumption (t _{ce})	Per capita consumption (t _{ce})	Per households consumption (physical unit)	Per households consumption (t _{ce})
Coal(t)	2.58	1.84	0.60	3.55	2.54
Electricity(kWh)	3106	0.382	0.13	3106	0.38
Fuelwood(t)	0.96	0.55	0.18	2.6	1.48
Liquefied	98.37	0.17	0.06	133.2	0.23
Natural gas(m ³)	64.81	0.09	0.03	510.3	0.68
Biogas(m ³)	20.80	0.02	0.01	1687.2	1.25
Solar energy(m ²)	1.61	—	—	3.87	—
Total	—	3.04	1.0	—	—

a. Per households consumption of all sample households refers to the average energy consumption of 1866 households;

b. Per households of energy consumption is averaged according to the actual number of users who use the energy.

c. Standard coal coefficient: raw coal, 0.7143kg standard coal/kg; electricity (equivalent), 0.1229kg standard coal/kWh; fuelwood, 0.571kg standard coal/kg; liquefied petroleum gas, 1.7143kg standard coal/kg; natural gas, 1.33kg standard coal/m³; Biogas, 0.74kg standard coal/m³.

d. According to the 2014 Beijing Statistical Yearbook, the household population is 3.05 person/household.

The total cost of all households is 4497 yuan, of which 2033 yuan of coal, 1840 yuan of electricity, which two accounting for 86% of the total cost. The specific data is in Table 2.

Table 2. All sample household, per capita energy consumption.

Energy Sources	All sample households	
	Per household (Yuan)	Per capita (Yuan)
Coal	2033	667
Electricity	1840	603
Liquefied petroleum gas	492	161
Natural gas	132	43
Total	4497	1474

3.3. District energy consumption situation

Overall, households in suburbs has higher per households consumption of coal, electricity, natural gas than outer suburbs, while has lower per households consumption of fuelwood.

From the aspect of coal consumption, Changping, Chaoyang, Fengtai, Haidian, Tongzhou farmers with a higher amount of coal, are more than 4 tons, including Fengtai and Haidian coal more than 5 tons, Miyun, Pinggu farmers per households consumption of coal had the lowest amount of less than 3 tons. For electricity consumption, Daxing, Fengtai and Shunyi households use a higher amount of annual electricity consumption of more than 4000 degrees, Yanqing, the lowest electricity consumption of the 1841 degrees. Huairou, Yanqing farmers have higher consumption of firewood, more than 3 tons, followed by Changping, Fangshan, Miyun, Pinggu and Shunyi, household consumption reached 2-2.5 tons, Chaoyang and Fengtai firewood consumption is zero. Chaoyang, Daxing, Fengtai, Haidian and Shunyi household use high amount of natural gas, Mentougou, Pinggu household gas consumption is very small, Huairou zero. The average amount of liquefied petroleum gas per capita Changping, Chaoyang, Mentougou and Tongzhou higher, reaching more than 130 kilograms, Yanqing the lowest.

The difference between the average coal consumption is mainly due to the average heating area, such

as Changping, Chaoyang, Fengtai, Haidian, Tongzhou farmers with a higher amount of coal, because these districts and counties have an average heating area of 110 square meters. The electricity consumption is related to the terrain characteristics of the district and the income of the household, such as Fengtai, Daxing, Shunyi, Haidian and Tongzhou household is in plain terrain with an average income of above 35,000 yuan, while Yanqing, Pinggu are a mountainous or semi-mountainous area with farmers bearing lower income.

Household energy costs differ in districts mainly due to the local level of economic development, farmer income and heating area and other factors, such as Haidian District, with relatively high income of farmers (39,000 yuan), more household appliances, larger household heating (135 m²), so coal costs and electricity costs are at a high level, and Yanqing is in the suburbs of mountainous areas, with poor economic conditions, thus farmers' energy expenditure is low.

Table 3. Household consumption and consumption expenses of energy users in different districts and counties.

District /County	Coal (t)	Coal (Yuan)	Electricity (kWh)	Electricity (Yuan)	Fuelwood (t)	Liquefied petroleum gas(kg)	Liquefied petroleum Gas (Yuan)	Natural Gas (m ³)	Total (Yuan)
Chaoyang	4.19	522	3554	2207	0	132	720	745.	8148
Fengtai	5.06	452	4823	2636	0	112	736	573.	7893
Haidian	5.24	450	3409	4207	1.27	118	354	550.	9065
Fangshan	4.01	260	2585	1435	2.08	120	968	415.	5012
Tongzhou	4.18	279	3659	1968	1.33	131	488	538.	5253
Shunyi	3.53	301	4944	2562	2.25	108	766	222.	6342
Changpin	4.32	349	3571	2475	2.29	129	506	250.	6476
Daxing	3.43	246	4510	2539	1.64	113	641	758.	5644
Mentougo	3.31	302	3105	1899	1.69	129	922	100.	5842
Huairou	3.40	274	3115	1616	3.15	118	837	0	5193
Pinggu	2.71	237	2091	1076	2.44	95	472	60.0	3923
Miyun	2.89	230	2539	1301	2.39	110	623	324.	4229
Yanqing	2.91	226	1841	1135	3.31	75	402	254.	3798

4. The countermeasures of rural energy adjustment

To complete of the task put forward in “Notice of Key Task Decomposition of the Beijing Clean Air Action Plan (2013-2017)” of reducing 1 million tons of coal-burning, rural energy structure adjustment must focus on the main body of energy consumption, heating manners and reducing energy consumption.

4.1. To promote the integration of urban and rural areas

Rural-urban continuum is a transition between the city and the township, suffering from intensive floating population, poor hygiene environment, traffic congestion and high energy consumption density. Village transformation in rural-urban continuum help farmers to achieve "rural-to-urban" routine, changing energy mode from scattered coal heating or fuelwood cooking into central heating, gas cooking, thus reducing the non-clean energy consumption.

4.2. Continue to promote the mountain relocation project

Since the implementation of mountain relocation in 2004, Beijing has moved a total of 34,000 farmers, 84,000 people. The relocation of farmers out of the long-term threat of geological disasters. New residential raises energy-saving level by 50%. The annual reduction of coal consumption is 0.5 million tons, equivalent to 0.4 million tons of coal equivalent.

4.3. To promote rural power grids, to promote the implementation of coal to electricity

According to the “Medium-term and Long-term Planning for the Beijing Power Network (2017-2020)”, Beijing intend to complete 250,000 rural households electric heating project between 2014 to 2017. Based on an annual modification of 62,500 households, each household can reduce coal 3.4 tons,

equivalent to an annual reduction of coal consumption of 213,000 tons. For the coal-to-electricity users, 10% users applies the air-sourced heating pump (Changping District data), the rest depends on the direct thermal or thermal heating technology. This demands an increase in electricity supply of 90 million degrees, equivalent to 11,100 tons of coal equivalent.

4.4. Digging building energy saving potential

Beijing maps a completion of about 100,000 households in energy conservation modification annually between 2014 and 2017, the city's rural housing generally meet the energy-saving insulation standards in 2017. According to the survey data, each household heating coal consumption is 2.58 tons, equivalent to 1.8 tons of standard coal. Combined with the current level of rural building insulation modification, in accordance with the transformation of 30% energy savings, the annual consumption of coal can be reduced 77,000 tons, equivalent to 55,000 tons of coal equivalent.

5. Conclusion

China's rural energy consumption structure is in the transition from non-commercial to commercial sources, and rural energy has become a key determinant to slow down the carbon emission growth. This paper systematically calibrates the current situation of rural energy consumption in Beijing by using the survey data of 1866 households in 13 districts and counties in Beijing based on the trend of energy supply and demand change in China.

The situation of rural living energy consumption is as follows: Among the surveyed households, the number of users in electricity, coal, liquefied gas ranked the top three. The per households consumption was 3.04 tons of coal equivalent and per capita energy consumption was 1.0 tons of coal equivalent. The total cost of all households is 4497 yuan, of which 2033 yuan of coal, 1840 yuan of electricity, which two accounting for 86% of the total cost. The district energy consumption can be seen in 3.3. Household energy costs differ in districts mainly due to the local level of economic development, farmer income and heating area and other factors.

In the end, the paper puts forward the rural energy structure adjustment path, with a view to promoting the use of clean energy in rural areas and reduce the environmental consequences of coal-burning .

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