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Comparative Study on Energy Consumption Structure of Ordinary Rural Households and Rural Tourism Households in Zhejiang Province, China

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Abstract

With the rapid development of rural tourism in China, more and more rural households operate a rural tourism business. The purpose of this study is to understand the energy consumption characteristic of ordinary rural households (ORHs) and rural tourism households (RTHs) in the mountainous area and islands area in Zhejiang province. 225 households were surveyed, including 185 ORHs and 40 RTHs, based on a field survey in Quzhou (mountainous area) and Zhoushan (islands area). Results reveal that energy consumption of ORHs is low, but energy comsumption of RTHs is high, about 3 to 5 times higher than that of ORHs. Given the results, the government and RTHs should pay more attention to take measures to reduce energy comsumption. Meanwhile, the factors affecting households' energy consumption are also analyzed. Energy consumption of ORHs is affected by frequently used area, family income level and permanent population. Then energy consumption of RTHs is mainly related to the total building area, number of air conditioner (AC), number of guestrooms and family income level.

Keywords

Rural Tourism, Ordinary Rural Households, Rural Tourism Households, Energy Consumption, Energy Structure

1. Introduction

Rural tourism has become an important pillar industry in China. According to the statistics released by the Ministry of Agriculture and Rural Affairs of China,

by the end of 2019 before COVID-19, the number of rural tourists had reached 3.09 billion, and there were more than 30 million business entities, with an operating income of nearly 850 billion yuan [1]. Obviously, the development of rural tourism definitely has increased farmers' income by providing tourism dwellings, catering services, leisure and entertainment, which has profound effects on the energy consumption patterns of rural households. However, the rapid growth of rural tourism also increased the demand for energy [2] and attracted attention to environmental protection.

Through literature review, a large and growing body of literature has investigated the current situation, characteristics and influencing factors of rural energy consumption in China. Tsinghua University conducted comprehensive research on energy consumption in rural areas of China in 2006 and 2007 respectively. The research results show that the energy consumption of rural households is increasing, and there is a tendency to exceed that of urban residential buildings [3]. Zou *et al.* studied the characteristics and influencing factors of rural energy use in China through field research [4]. Wu *et al.* analyzed the household energy consumption characteristics in rural China based on the panel data from 2002 to 2013 [5]. Xin *et al.* compared and analyzed the changes in rural energy consumption and structure in Northeast China from 2002 to 2017 through a field survey [6]. Gao *et al.* took Hunan Province as an example to study the impact of government policies on the energy consumption structure in rural areas [7]. Wang *et al.* investigated the energy consumption of rural households in traditional villages in Zhejiang province [8].

The existing literature above mentioned on rural energy consumption is extensive and focuses particularly on ORHs, there are relatively few historical studies in the area of RTHs. However, the impact of the development of rural tourism on farmers' energy consumption patterns has also attracted increasing attention. Xi *et al.* [9] and Zhang *et al.* [10] studied the household energy consumption patterns and influencing factors of rural households in scenic spots, and the results showed that the living energy consumption of rural tourism farmers was significantly higher than that of traditional farmers.

Zhejiang is famous for RT, and the development of RTBs is at the forefront in China [11]. Furthermore, the number of key rural tourism villages recognized by the state ranks first [12]. However, rural energy consumption is characterized by the different regions, climates, natural resources, economies, lifestyles and other factors, which means the representativeness of existing survey data is limited [4]. Therefore, the energy consumption of RTHs in Zhejiang province is worth studying. This research aims to understand the status of energy consumption of ORHs and RTHs in mountain areas and island areas, and study the influence factors on energy consumption.

2. Data and Analysis

2.1. Data Collection

Due to the lack of official statistics on individual household information and

energy consumption in China, field surveys were carried out to collect relevant data. Field surveys were carried out by questionnaires. The investigators con-ducted a face-to-face survey by asking people to fill out questionnaires, and carefully recorded the data. Interviewers were professionally trained before being assigned field investigations. To ensure that the acquired information was valid, the survey team also talked with the village leaders to make out and gain a com-mand of the overall status of the village, and, whenever possible, they would check the validity of the collected data for at least two times. In addition, the whole building was mapped and photographed, and the function and status of each room were recorded in detail. Field measurements were also adopted to monitor electricity consumption and energy-consuming behaviors of farmers and tourists by using instruments.

In addition, some details were gained from the government for more detailed and accurate data. For example, the monthly electricity consumption of the rural households surveyed was provided by local Power Supply Bureau, and the village topographic map was obtained from local Planning Department. Finnally, 225 households including 185 ORHs and 45 RTHs, were detailed investigated in Quzhou, and Zhoushan during 2016 to 2019. More than 100 questionnaires were collected from tourists, and the EC and indoor thermal comfort of 25 gues-trooms were monitored continuously for 3 days. The survey contents include four aspects:

1) Basic information of rural households: the number of family population, the permanent residential population, main source of income, household in-come of the past three years, the number of guestrooms, gender, career, age, electric appliances, etc.

2) Basic information of rural residential buildings: built time, building area, number of stories, building structure, building material and construction, etc.

3) Energy consumption: the consumption of electricity, LPG, firewood, re-newable energy, etc.

4) Energy use behavior: the schedule of using household appliance, occupancy rate, energy use behavior of farmers and tourists.

2.2. Characteristics of Energy System

Field survey results reveal that the energy consumption of rural households mainly relies on commercial energy, especial electricity. Electricity is used for cooling, heating, lighting, electric appliances, cooking and hot water. Except electricity, cooking mostly depends on LPG. In some mountainous areas of Quzhou, firewood is also used for heating, cooking. Solar energy, as a kind of renewable and clean energy, is widely used for hot water.

2.2.1. Commercial Energy Consumption

Figure 1 is the monthly electricity consumption (EC) of ORHs in Quzhou and Zhoushan, which shows two-peak EC period in a year. The monthly EC in win-ter and summer are obviously higher than the other months. In addition, the EC

in winter is slightly lower than that of in summer. The questionnaire survey reveals that the farmers are not used to using air conditioner in winter. During transitional seasons, the EC is relatively lower. However, the EC in autumn is higher than late spring and early summer. Furthermore, the EC in Quzhou is higher than in Zhoushan, due to farmers also use firewood for cooking.

Figure 2 shows the EC of RTHs has an obvious peak-valley fluctuation trend both in Quzhou and Zhoushan. The questionnaire survey indicates that the time of the rural tourism operation phase is from April to November. Therefore, the EC of RTHs in heating and cooling period is unbalanced, and the EC of cooling period in summer is obviously higher than that of heating period in winter.

As shown in Figure 3, there is a significant difference between the annual EC of ORHs and RTHs. The EC of RTHs is obviously higher than that of ORHs, which is caused by operating rural tourism business. The average annual EC of ORHs in the two areas are relatively close, which is 1001.67 kWh in Quzhou,

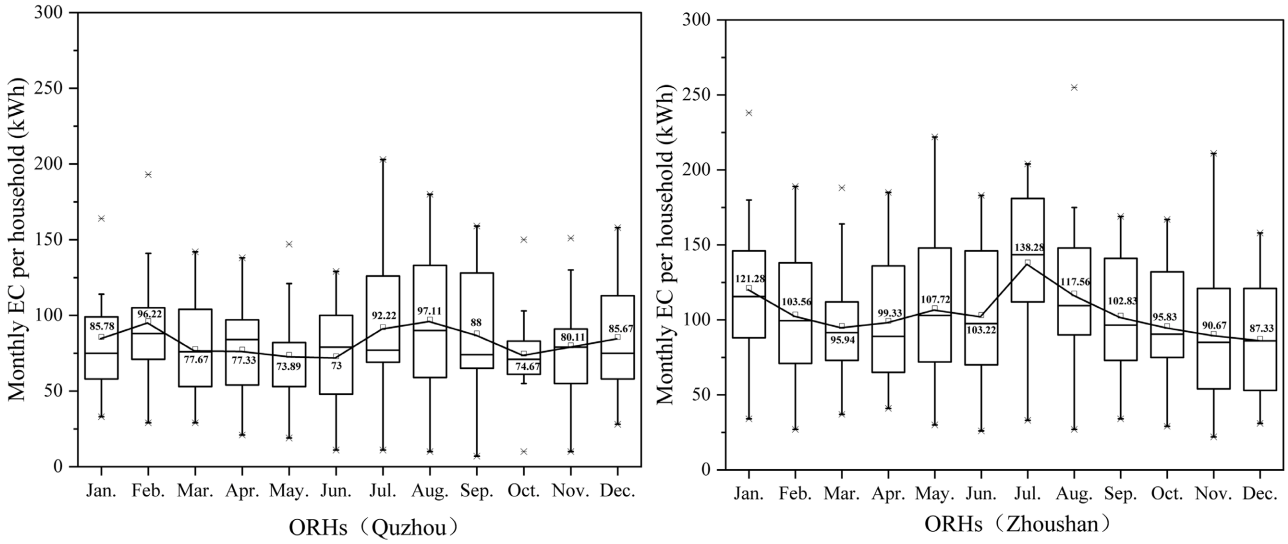


Figure 1. Monthly EC of ORHs in Quzhou and Zhoushan.

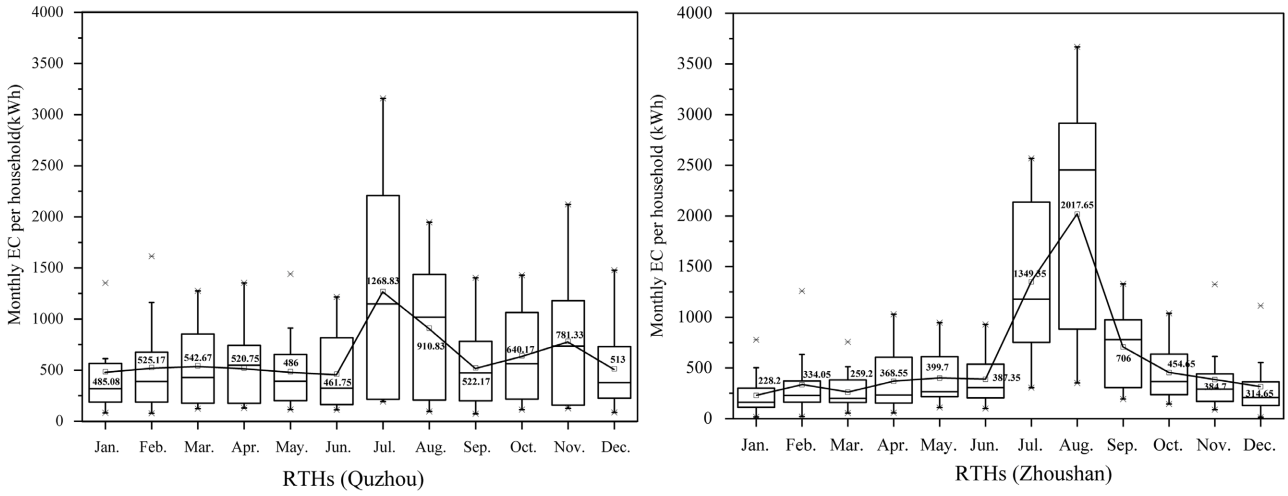


Figure 2. Monthly EC of RTHs in Quzhou and Zhoushan.

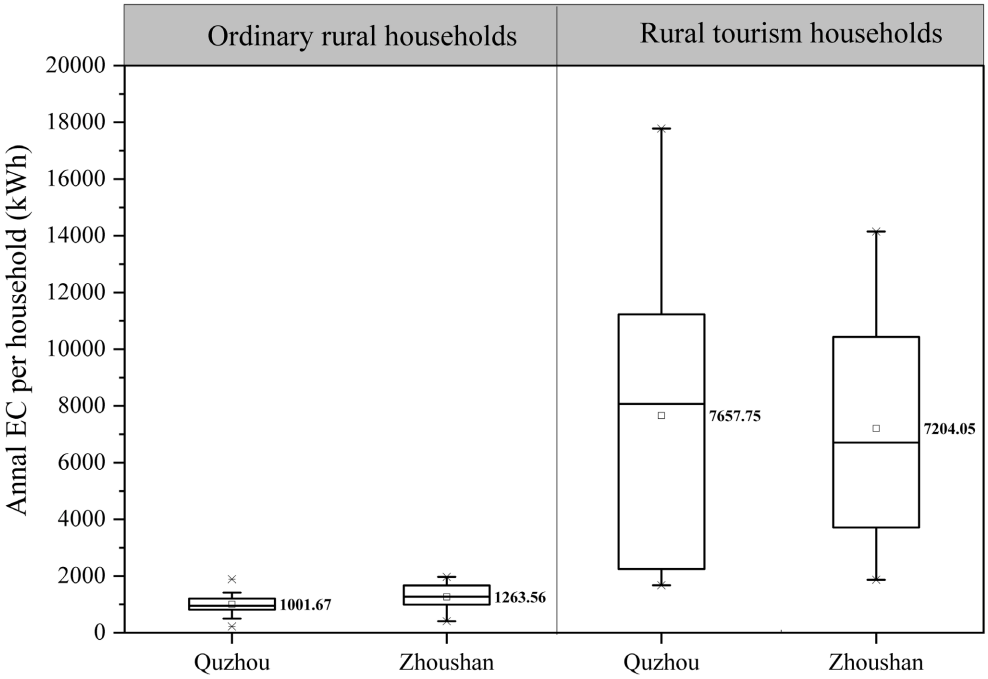


Figure 3. Annual EC of ORHs and RTHs.

and 1263.56 kWh in Zhoushan. Compared with the average annual EC of RTHs in Quzhou and Zhoushan, is 7657.75 kWh and 7204.05 kWh, which about 7.6 times and 5.7 times higher than ORHs respectively.

Pipe-line gas is very common in cities and towns in Zhejiang province. However, canned LPG is still the main fuel in rural areas, because it is more convenient for delivery. The official file [13] stipulates five standard models of cylinder and the one that farmers in Zhejiang Province commonly used is YSP35.5, whose volume is 35.5 L and maximum filling weight is 14.9 kg. The LPG consumption was converted into standard coal (GJ).

LPG consumption of households is clearly shown in **Figure 4**. The annual LPG consumption is 0.40 GJ per capita in Quzhou, and 0.75 GJ per capita in Zhoushan. It is obvious that LPG consumption in Zhoushan is higher than Quzhou. The annual LPG consumption of RTHs is 3.52 GJ per capita in Quzhou, and 5.85 GJ per capita in Zhoushan. LPG consumption in Zhoushan is higher than Quzhou. LPG consumption of RTHs is higher than ORHs on average, about 8.8 times and 7.8 times higher, respectively.

The comparison above shows that the LPG consumption of RTHs is far higher than that of ORHs. The LPG consumption of RTHs in Zhoushan is the highest, followed by Quzhou. Because rich in biomass energy in mountainous areas, farmers always use firewood as their energy sources instead of LPG. However, due to a lack of biomass energy and higher economic development level, RTHs in Zhoushan mainly use LPG for cooking.

2.2.2. Non-Commercial Energy Consumption

Firewood is the most widely used non-commercial energy resources. The com-

parison of firewood consumption between ORHs and RTHs is shown in Figure 5. The annual firewood consumption was obtained by questionnaire, and then convert into standard coal. The annual firewood consumption of ORHs is 7.69 GJ per capita in Quzhou and 1.05 GJ per capita in Zhoushan. It is obvious that

Figure 4. LPG consumption of ORHs and RTHs.

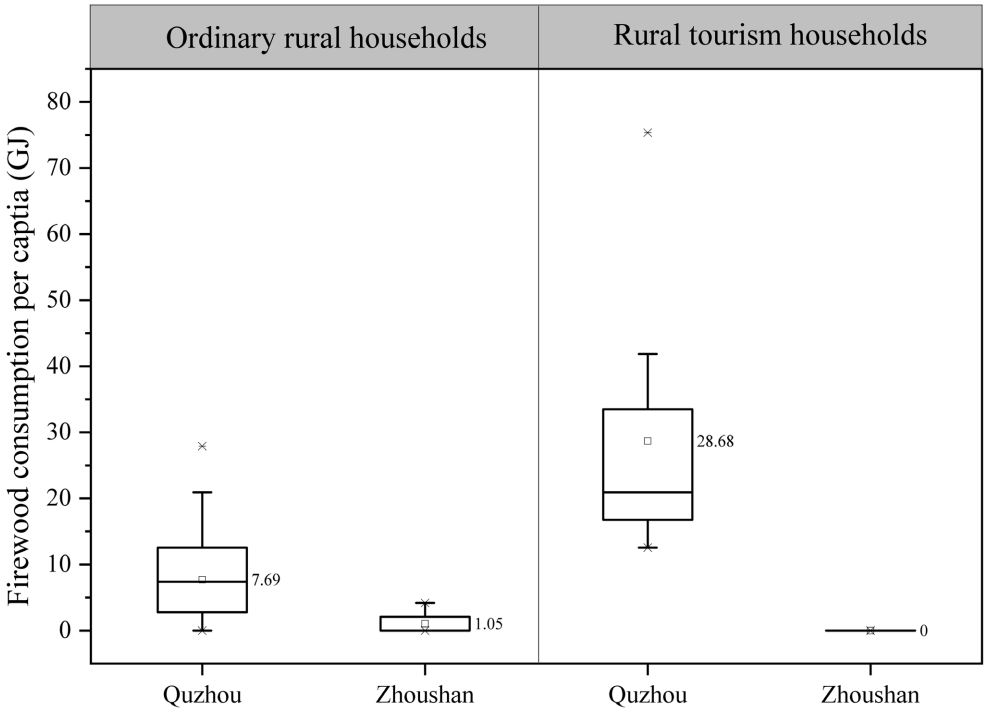


Figure 5. Firewood consumption of ORHs and RTHs.

firewood consumption in Quzhou is higher than that in Zhoushan. Some households use less firewood than LPG and electricity. On the contrary, some households still mainly relay on firewood and barely use LPG and electricity. According to the investigation, farmers use 7.5 kg to 10 kg firewood per day on average.

As shown in Figure 5, the annual firewood consumption of RTHs is 28.68 GJ per capita in Quzhou. However, RTHs rarely use firewood in Zhoushan. Traditional hearth is seldom seen in kitchens in RTHs in Zhoushan, especially those in modern buildings, in which their kitchen facilities share the same features as those of urban families. Most of RTHs in Quzhou still use traditional hearth for cooking, and take it as a major feature to distinguish urban life. As a result, firewood is still an important energy resource in these RTHs.

The survey also reveals that farmers still use straw in some ORHs in Quzhou, but not very much. Coal (primarily briquettes) also used but takes only a small portion of all energy resources and, therefore, can be ignored in statistical analysis.

2.2.3. Renewable Energy Consumption

Solar energy is widely used in Zhejiang rural areas. Solar water heater is the most common way of using solar energy. According to Table 1 obtained by field survey, the average solar water heater owned by ORHs is 0.8 to 0.9 sets per household in ORHs. However, greatly influenced by whether, it is difficult to ensure hot water supply for people living there. Therefore, electrical heating mostly assists solar water heater. It is quite difficult to obtain the accurate usage of hot water for shower. According to the standard [14], we supposed that the flowing rate of water should be 0.04 L/s, and farmers usually take shower 3 times a week, with 15 minutes each time. Thus, it amounted to 36 L hot water per capita every time. The total amount of heat supplied by the solar energy was 75%. The average annual consumption of solar energy per capita can be calculated by the following equation:

$$E_{SE,avg} = \frac{1}{n}(c \times m \times \Delta t) \times r \tag{1}$$

where, c stands for specific heat capacity of water, which is 4.2×10^3 J/(kg·˚C). m stands for mass of water. Δt stands for the change of the temperature. r stands for utilization rate, %.

According to the questionnaire, there are 1.5 sets of solar water heater in each RTHs in Quzhou, while 1.25 sets in Zhoushan. As mentioned above, greatly influenced by weather, it is quite difficult to ensure the water supply. With promotion and application of air source heat pump, as shown in Table 1, there is an increasing number of RTHs adopt assemble system of solar energy and air-sourced heat pump, which has reached to 0.6 sets per household in Quzhou and Zhoushan. The working principle of the system is that solar water heater serves as the first heating system to increase water temperature. Then, the air source heat pump works as the second heating system to ensure the stability of terminal water supply. In order to guarantee sufficient supply of the hot water,

RTHs always keep the air source heat pump open. Hot water is provided by both solar energy and air-sourced heat pump simultaneously, which makes it difficult to analyze all the data acquired through the investigation according to tourists' water consumption. We assumed that solar energy is utilized almost in every aspect, while the insufficient part is provided by air-sourced heat pump. The calculation is made according to the quantity of solar radiance provided by Typical Meteorological Database for China's Building Energy Efficiency [15]. So, the average annual consumption of solar energy per capita can be calculated by the following equation:

$$E_{SE,avg} = \frac{1}{n}\left(Q \times N \times S \times \beta\right) \tag{2}$$

where, Q is solar radiation, MJ/(m^2·y); N is the average ownership of solar water heater per household; S is the collecting area of solar water heater, m^2; β is the heat collection efficiency, %.

According to the Equations (1) and (2), the result is shown in Figure 6. The solar energy of ORHs was 0.63 GJ per capita in Quzhou, and 0.52 GJ per capita in Zhoushan. The solar energy consumption of RTHs in Quzhou and Zhoushan are 4.95 GJ per capita and 6.04 GJ per capita, respectively.

2.3. Personnel Activities and Equipment Use

Energy use behavior of farmers and tourists has been conducted by questionnaire and instrument monitoring. The people's occupancy rate of farmers and tourists shown in Figure 7 means the ratio people in their bedroom. As shown in Figure 7, farmers of ORHs usually get up early in the morning. About 33%

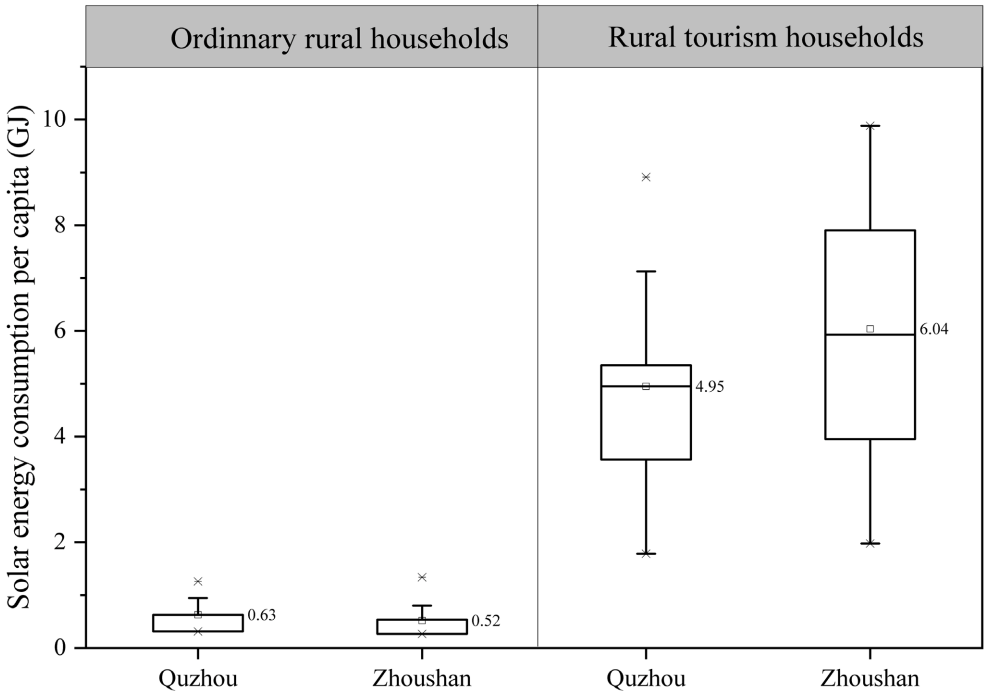


Figure 6. Solar energy consumption of ORHs and RTHs.

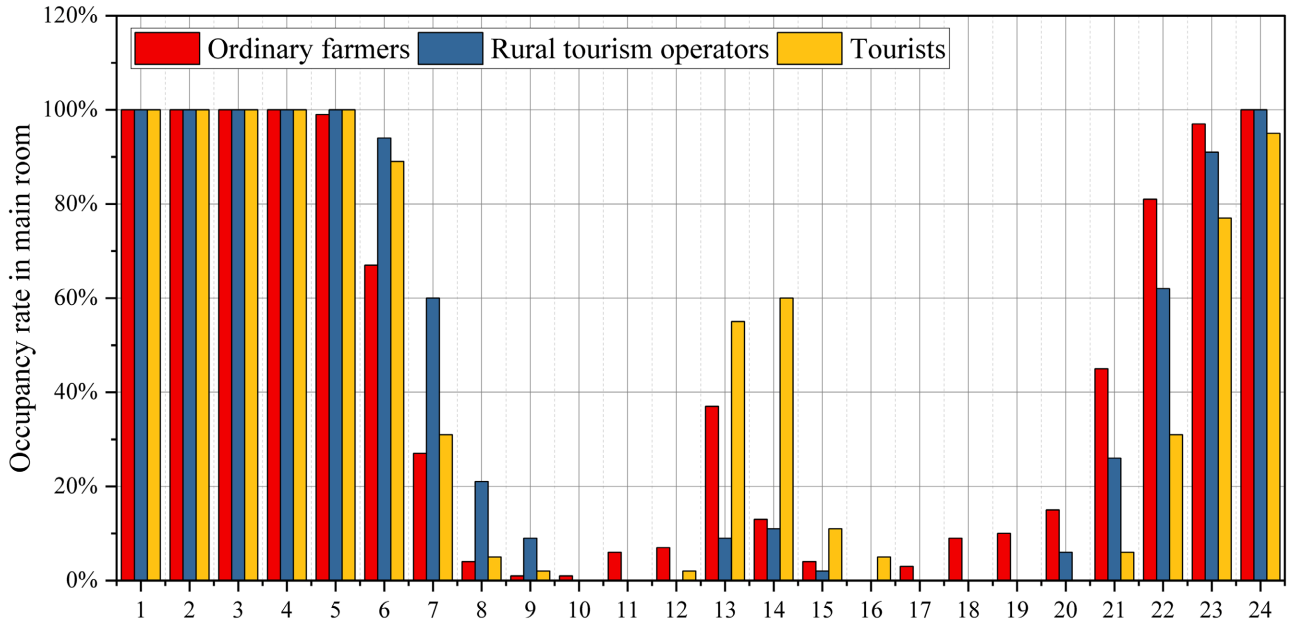


Figure 7. People's occupancy rate of rural households and tourists.

farmers get up at around 6:00 am; about 55% farmers go to bed at before 21:00 pm, and about 37% of them take noon break for about one hour. However, farmers of RTHs have changed their traditional production style, and life style and personnel activity have also experienced many changes. Usually, they get up and go to bed one hour later than farmers of ORHs. Compare with tourists, they often get up earlier than tourists get and go to bed later than tourists do. **Figure 7** shows the tourists usually lead a relatively regular life. Specifically, they get up between 6:00 am and 7:00 am, and then have breakfast between 7:00 am and 8:00 am, while have lunch between 11:30 am and 12:00 pm, and super time is about from 17:00 pm to 18:30 pm. They often go to bed later than farmers do, about from 21:00 pm to 23:00 pm. About 60% of tourists take a little snap after lunch for one or two hours between 12:00 pm and 13:00 pm.

Energy consumption also closely related to the number and time of using electrical appliances. The family-owned appliances per household of ORHs and RTHs are list in **Table 1**. The schedule of using electrical appliances in a whole day is shown in **Figure 8**. The part in bold represents the household appliances under operation. As is shown in **Table 1**, the ownership of air conditioner, washing machine, lampblack absorber, refrigerator, solar water heater and so on nearly reaches one set per household. Some appliances like TV, electric fan is more than one set for each household.

3. Analysis of Energy Consumption Structure

3.1. Energy Resource Type and Structure

The consumption of LPG, coal, firewood was calculated according to the questionnaire. The electricity consumption was provided by local power supply bureau. All the energy consumption was converted into standard coal. The average

Table 1. Family-owned appliances per household of ORHs and RTHs.

Appliance		ORHs		RTHs	
		Quzhou	Zhoushan	Quzhou	Zhoushan
Cooking & Hot water	Rice Cooker	0.7	1.0	2.0	2.4
	Lampblack absorber	0.6	1.0	1.0	1.0
	Electric kettle	1.0	1.3	12.0	9.5
	Solar water heater	0.8	0.9	1.15	1.25
	Air source heat pump water heater	0	0	0.6	0.6
Cooling & Heating	Air conditioner	0.8	1.1	11.3	11.7
	Electric warmer	0.5	0.6	0.1	0.1
	Electric blanket	1.0	0.5	0	0.1
	Electric fan	2.1	2.5	12.7	2.8
Lighting	Energy-saving lamp	8.0	7.0	31.5	35.2
	Incandescent lamp	3.0	2.3	1.5	1.2
Others	TV	1.5	2.2	12.0	11.6
	PC	0.2	0.4	1.4	1.5
	Washing machine	1.0	1.0	1.1	1.2
	Refrigerator	1.0	1.0	2.1	2.6

annual consumption of each type of energy per capita can be calculated by the following equation:

$$E_{N,avg} = \frac{1}{n}\sum_{i=1}^{n} \beta_i E_{N,i} \tag{3}$$

where, N stands for the energy type, n stands for the number of people in surveyed households, $E_{N,i}$ stands for the annual consumption of the Nth-type-energy of ith surveyed household, β_i stands for the corresponding conversion coefficient to average low calorific value, which is 3600 KJ/KWh for electricity, 50,179 KJ/kg for LPG and 16,726 KJ/kg for firewood [16].

Therefore, from the above equation, the total average annual energy consumption per household can be calculated with the following equation:

$$E_{hh,avg} = E_{electricty,avg} + E_{LPG,avg} + E_{firewood,avg} + E_{SE,avg} \tag{4}$$

Consumption of commercial energy, non-commercial energy and new energy of ORHs is shown in **Figure 7**. The total annual energy consumption is 9.54 GJ per capita in Quzhou. And specifically, electricity consumption is 0.82 GJ per capita, accounting for 8.6%; LPG is 0.4 GJ per capita, accounting for 4.2%; firewood is 7.69 GJ per capita, accounting for 80.6%; solar energy is 0.63 GJ/per capita, accounting for 6.6%. The total annual energy consumption is 3.66 GJ per capita in Zhoushan; electricity is 1.34 GJ per capita, accounting for 36.6%; LPG

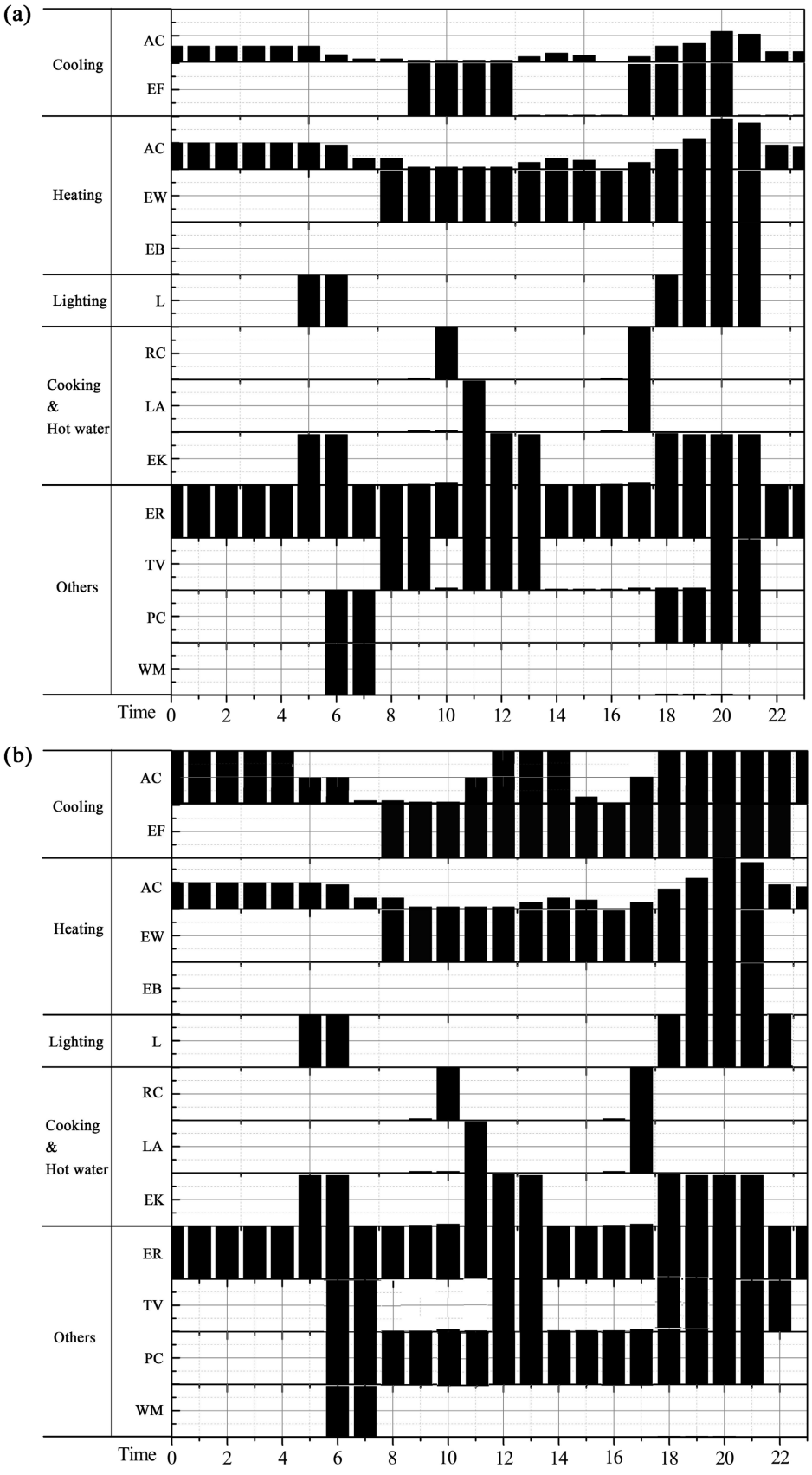


Figure 8. Electric appliances usage frequency of ORHs and RTHs. (a) ORHs; (b) RTHs.

is 0.75 GJ per capita, accounting for 20.5%; firewood is 1.05 GJ per capita, accounting for 28.7%; solar energy is 0.52 GJ per capita, accounting for 14.2%. As can be seen from the data, the energy consumption in Zhoushan is lower than that in Quzhou, because of the higher consumption of firewood. The commodity energy in Zhoushan, such as EC and LPG, is higher than Quzhou.

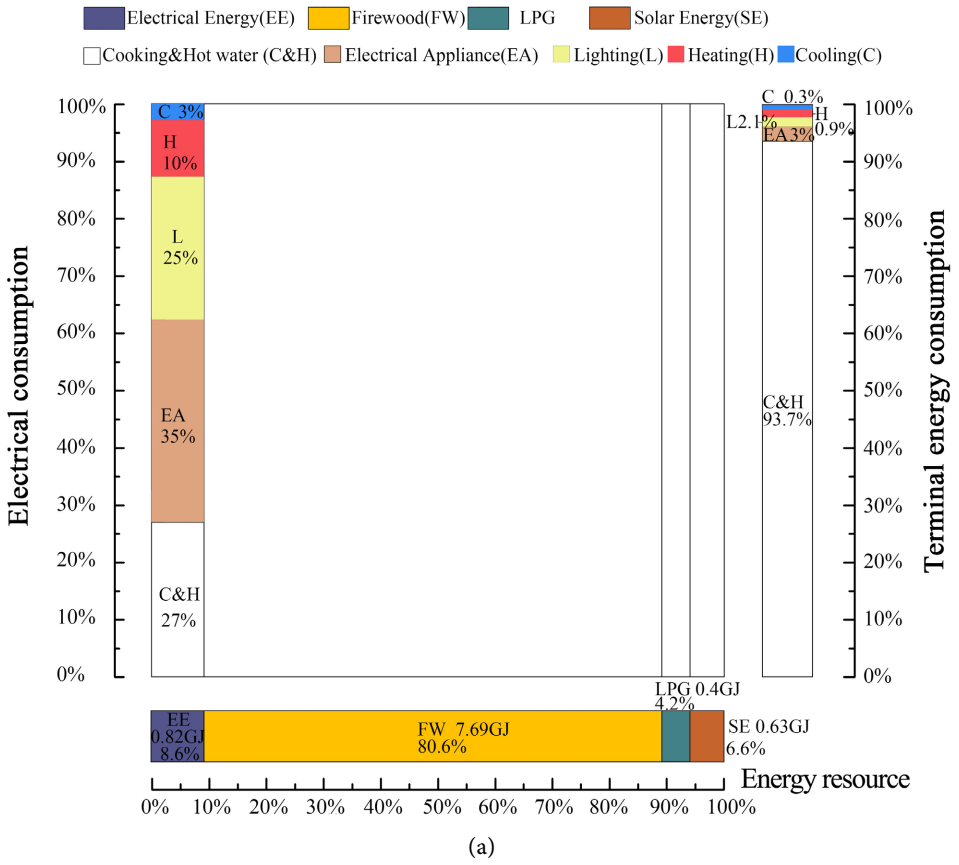
As shown in **Figure 7**, the total annual energy consumption of RTHs is 43.02 GJ per capita in Quzhou; among the total energy consumption, electricity is 5.87 GJ per capita, accounting for 13.6%; LPG is 3.52 GJ per capita, accounting for 8.2%; firewood is 28.68 GJ per capita, accounting for 66.7%; solar energy is 4.98 GJ per capita, accounting for 11.5%. The total annual energy consumption is 18.71 GJ per capita in Zhoushan; electricity is 6.82 GJ per capita, accounting for 36.5%; LPG is 5.85 GJ per capita, accounting for 31.3%; but no firewood is consumed; solar energy is 6.04 GJ per capita, accounting for 18.71%. Therefore, energy consumption in Zhoushan is lower than that in Quzhou. The annual energy consumption per capita for RTHs is 3 to 5 times higher than that of ORHs.

3.2. Terminal Energy Consumption and Structure

Terminal energy consumption can be classified into five parts: heating, cooling, lighting, electric appliances, cooking and hot water. Firewood, LPG and solar energy is usually used for cooking and hot water. Electricity covers five aspects of rural residential energy consumption, which is also the most difficult part in decomposition. As the service time of equipment comes from the general estimation of respondents, the results influenced by factors such as depreciation of equipment, and it is also very difficult to count the exact proportion. Therefore, the calculation is based on appropriate assumptions.

The calculation of terminal energy consumption is made in accordance with the sets of appliances, appliance power, total service time (service time per day multiples the number of days) and usage probability under investigation. According to existing research results [17], if the indoor temperature of rural buildings is lower than 30˚C in summer, and is higher than 8˚C in winter in hot summer and cold winter zone, the indoor thermal environment is considered to be relative comfortable and is acceptable. Therefore, the service time of air conditioner, electric blanket and electric warmer sees an increase when outdoor temperature is over 35˚C or below 5˚C when the air conditioner works in summer and winter. The exact running time is available according to the probability of use within 24 hours. Some appliances have relatively fixed usage time, such as TV, refrigerator, rice cooker, washing machine, etc. The usage time counted in accordance with the average time. During the estimation, depreciation of equipment is not taken into consideration, and the estimation is revised according to the use frequency of all the equipment and the usage habits of farmers surveyed.

As shown in **Figure 9(a)**, the annual electricity consumption of ORHs is 0.82 GJ per capita in Quzhou. The proportion of electric appliance is the highest, accounting for 35%, followed by cooking and hot water, which account for 27%.


Electrical Energy(EE)
Firewood(FW)
LPG
Solar Energy(SE)
Cooking&Hot water (C&H)
Electrical Appliance(EA)
Lighting(L)
Heating(H)
Cooling(C)
Electrical consumption
Terminal energy consumption
C 3%
H 10%
L 25%
EA 35%
C&H 27%
C 0.3%
H 0.9%
EA 3%
C&H 93.7%
LPG 0.4GJ 4.2%
EE 0.82GJ 8.6%
FW 7.69GJ 80.6%
SE 0.63GJ 6.6%
Energy resource
(a)
C 6%
H 8%
L 23%
EA 31%
C&H 32%
C 2.2%
H 2.9%
L 8.4%
EA 11.3%
C&H 75.1%
EE 1.34GJ 36.6%
LPG 0.75GJ 20.5%
FW 1.05GJ 28.7%
SE 0.52GJ 14.2%
(b)

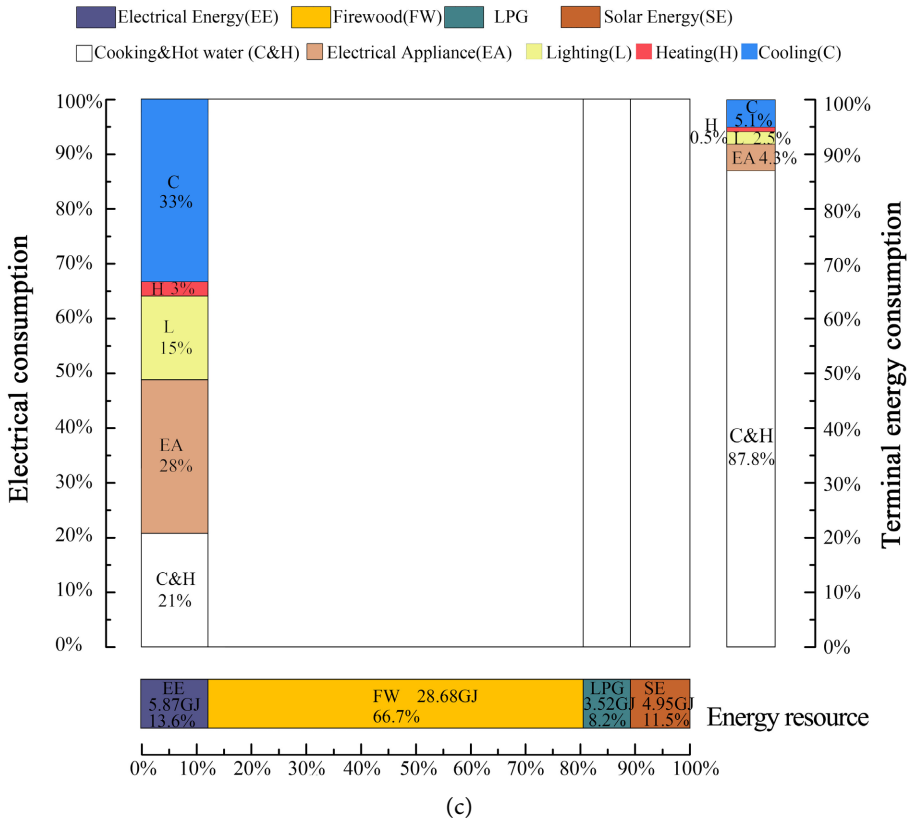


Figure 9. Energy consumption structure of ORHs and RTHs. (a) ORHs (Quzhou); (b) RTHs (Quzhou); (c) ORHs (Zhoushan); (d) RTHs (Zhoushan).

The electricity consumption for lighting accounts for 25% while heating and cooling account for the lowest, with 10% and 3% respectively. The total annual terminal energy consumption is 9.54 GJ per capita. Cooking and hot water, accounting for 93.7%, takes up the highest, which is followed by electric appliances and lighting, accounting for 3% and 2.1% respectively. Heating and cooling account for the lowest with only 0.2% and 0.1%, respectively. It suggests that the energy consumption of heating and cooling of ORHs is very little, and energy is primarily used for cooking and hot water.

Figure 9(b) shows that the total annual electricity consumption of ORHs in Zhoushan is 1.34 GJ per capita, in which the proportion of cooking and water is the highest, accounting for 32%, followed by appliance, accounting for 31%. The electricity consumption for lighting accounts for 23%, and heating and cooling accounting for the lowest, about 8% and 6% respectively. The total annual terminal energy consumption is 3.66 GJ per capita, in which the proportion of cooking and hot water is the highest, accounting for 75.1%; electric appliance is the next, accounting for 11.3%; lighting, accounting for nearly 8.4% and energy consumption of heating and cooling is the lowest, accounting for 2.9% and 2.2% respectively. By comparison with the energy consumption of ORHs in Quzhou, ORHs in Zhoushan consume higher EC, but total annual terminal energy consumption are lower, where households are still mainly consuming firewood. In addition, cooking and heating consume more energy than others do.

As is shown in Figure 9(c), the annual EC of RTHs in Quzhou is 5.87 GJ per capita. Cooling is the highest, accounts for 33% and then followed by electric appliance, accounting for 28%. Cooking and hot water accounts for 21%; lighting 15%; while heating is the lowest, accounting for 3%. The total annual terminal energy consumption is 43.02 GJ per capita. The proportion of cooking and hot water is the highest, accounting for 87.8% and that of cooling, electric appliance, lighting and heating accounts for 5.1%, 4.3%, 2.5%and 0.5%, respectively.

Figure 9(b) indicates the annual EC of RTHs in Zhoushan is 6.82 GJ per capita. Cooling is the highest, accounting for 39%, and then followed by electric appliance, accounting for 26%. Cooking and hot water account for 20%; lighting 13%; heating 2%, which is the lowest. The total annual terminal energy consumption is 18.71 GJ per capita. Cooking and hot water is the highest, accounting for 68%; the following three are cooling, electric appliance and lighting, accounting for 15.6%, 10.4% and 5.2% respectively. Heating is at the lowest level, accounting for 0.8%.

Similar to ORHs, the EC of RTHs in Zhoushan is higher but total annual terminal energy consumption is lower than in Quzhou, due to the consumption of firewood. With regard to electricity consumption, cooling is the highest, with a number between 29% and 39%. In terms of annual terminal energy consumption, cooking and heating are higher than others are.

4. Correlation Analysis

There are three methods for calculating linear correlation coefficient: Pearson's

correlation coefficient (r), Spearman ranking correlation coefficient (r) and Kendall correlation coefficient (τ). The Pearson's correlation coefficient (r) is the simplest and wildly used measure of strength for linear dependence between two variables. In this study, correlation analysis of parameters was carried out by SPSS19.0. All the data was checked before any comparison was made to ensure it is normally distributed. Variables that do not meet this condition of normality with a value larger than 1 for skewness (a measure of asymmetry) and kurtosis (a measure of "peakedness") were transformed before being assessed in SPSS19.0.

Energy consumption is influenced by various kinds of factors such as weather conditions, production modes, availability of energy, income level, energy cost, availability of energy-saving technology, policies and systems, etc. Energy consumption of rural household is not only related to building, but also to people activities and the use of equipment. To be specific, factors relating to building are the shape, window-to-wall ratio and average gross floor area per capita and so on. Factors related to family include the proportion of permanent residents and the population age structure. The factor associated with equipment is mainly the number of air conditioner. The impact of all the factors on building energy consumption is analyzed as follows.

Pearson's correlation coefficient (r) is a measure of the strength of linear dependence between two variables by means of a value between −1 and +1 (inclusive). The coefficient of determination (R^2) can be calculated by squaring the Pearson's r. In other words, R^2 represents the proportion of variability in one variable accounted for by another variable. The values range from 0 to 1, in which 1 indicates a perfect fit. The p-value is a measure of the probability of obtaining a result at least as extreme as the one that is actually observed, so the lower the value is (usually below 0.05 or 0.01), the more significant the result will be.

4.1. Influence Factor of Energy Consumption of ORHs

In this section, six parameters were analyzed, which have the correlation with annual energy consumption per household: frequent used area ($r = 0.593$, $p = 0.000 < 0.01$); family size ($r = 0.199$, $p = 0.170$); number of AC ($r = 0.246$, $p = 0.088$); income level ($r = 0.412$, $p = 0.004 < 0.01$); permanent population (living at home for more than 6 months) ($r = 0.323$, $p = 0.024 < 0.05$); total building area ($r = 0.198$, $p = 0.172$). It can be seen that three variables are significantly correlated with energy consumption: frequent used area, income level, and permanent population. Frequent used area has a significant correlation with energy consumption ($r > 0.5$). As indicated by the positive correlation coefficient, it is easily understandable that as frequent used area grows, the energy consumption also grows. When it comes to income level ($0.3 < r < 0.5$), it shows that the higher the family income is, the higher the energy consumption is, which is different from previous studies that showed no correlation between income and energy consumption. Besides, permanent population has a weaker correlation ($r < 0.3$) than frequent used area and income level. Family size does not have a significant

correlation with energy consumption, because young labors are working outside. The scatter plot of annual energy consumption per household and frequent used area, income level and permanent population are shown in Figure 10.

Although the total building area does not have a significant correlation with energy consumption, it cannot be ascertained that there are no indirect connections between them. The results show that the total building area is significantly correlated to frequent used area, while the latter is significantly correlated to energy consumption. As a result, the total building area has an indirect impact on energy consumption.

In addition, though the number of air conditioner shows no correlation with annual energy consumption per household, it has a negative correlation with annual electricity consumption per household, which is weak ($R^2 < 0.1$). The previous study conducted by Chen *et al.* [18] also showed that there was a positive

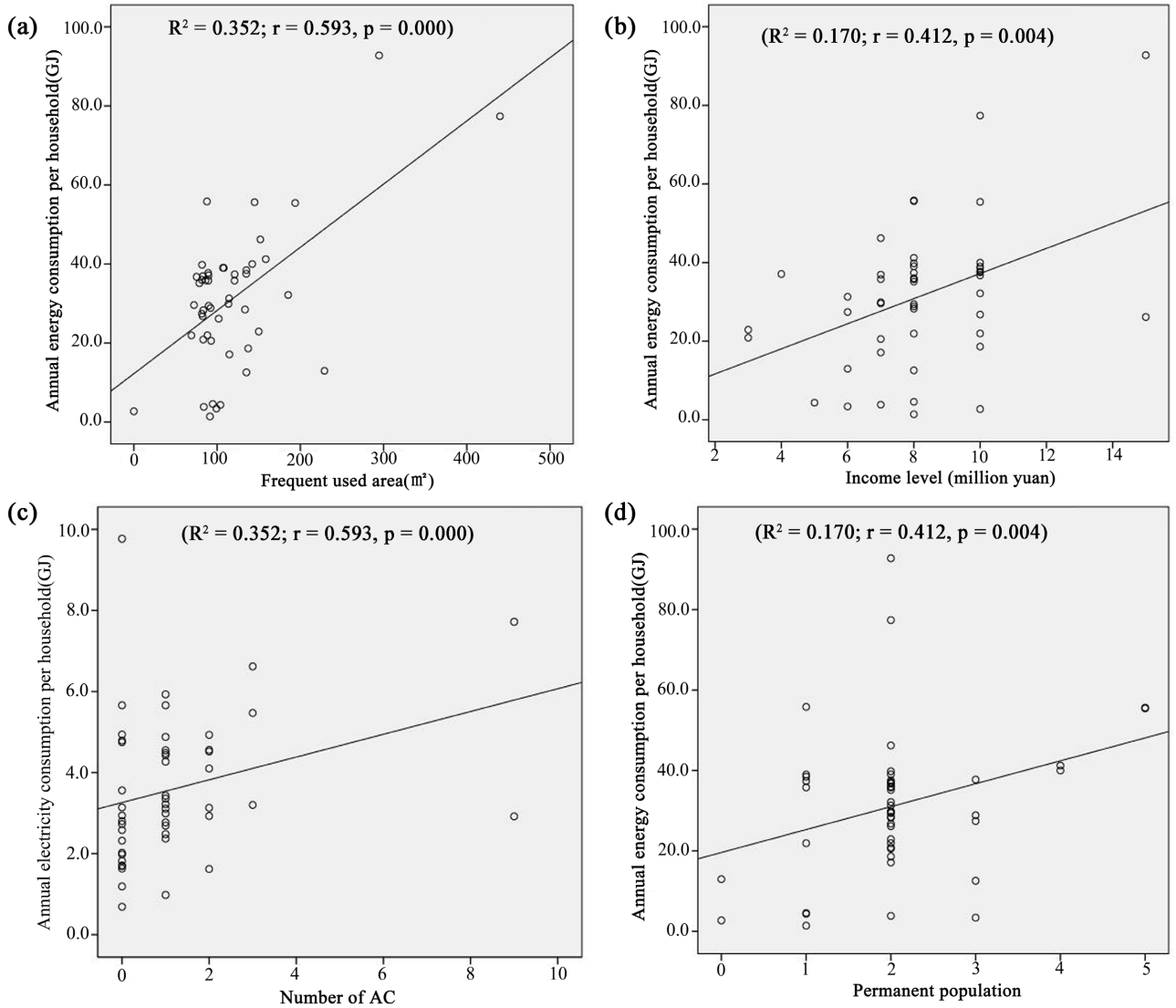


Figure 10. Scatter plot of annual energy consumption per household and frequent used area, income level, permanent population and number of air conditioner. (a) Frequent used area; (b) Income level; (c) Permanent population; (d) Number of AC.

correlation between air conditioner and electricity consumption.

4.2. Influencing Factors of Energy Consumption of RTHs

Taking RTHs in Zhoushan as an example, it has been shown that the total annual energy consumption per household is significantly correlated with: total building area (r = 0.779, p = 0.000); number of AC (r = 0.755, p = 0.000); number of guestroom (r = 0.671, p = 0.001); income level (r = 0.661, p = 0.001). The scatter plot of annual energy consumption per household and total building area, number of AC, number of guestroom and income level are all shown in Figure 11. It shows that energy consumption has no correlation with family size or permanent population, which suggests that the farmers of RTHs use less energy than tourists.

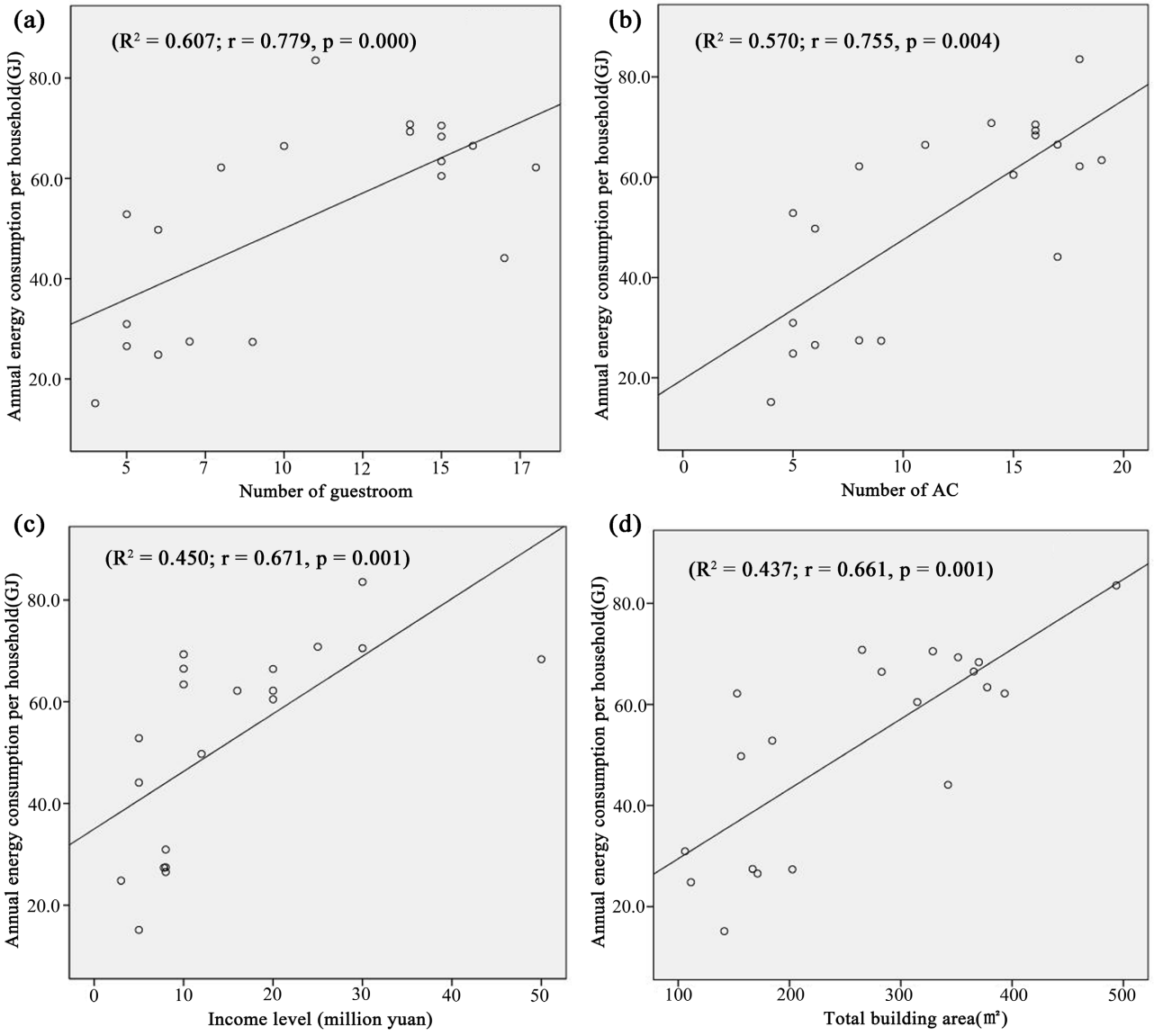


Figure 11. Scatter plot of total annual energy consumption per household and total building area, number of AC, number of guestroom, income level. (a) Permanent population; (b) Number of AC; (c) Number of guestroom; (d) Income level.

Among those four variables, total building area and number of AC have had the most significant correlation with annual energy consumption per household, which is followed by the number of guestroom and income level. As indicated by the positive correlation coefficient, it can be easily understood that, when the factors such as area, air conditioner ownership, the number of guestroom and income grow, the energy consumption also increases. In addition, the four variables appear to be significantly correlated with each other. Households those have higher income have greater investment into rural tourism business.

Additionally, as is suggested by the survey, the number of guestrooms is an important parameter, which has a significant positive correlation with annual energy consumption per capita, annual electricity consumption per capita as well as annual LPG consumption per capita, with the Pearson's correlation coefficient of 0.732, 0.719 and 0.476 respectively. It reveals that the number of guestroom has a more significant influence on electricity consumption than LPG consumption. The results of terminal energy consumption show that cooling energy consumption accounts for 39%, and the use of air conditioners has a dominant effect on energy consumption in summer. Therefore, special attention should be paid to tourists' use of air conditioner in summer.

5. Conclusions

This study reveals the perspective of energy consumption trends, energy consumption patterns, energy structure and renewable energy development of ORHs and RTHs in mountainous areas (Quzhou) and inland areas (Zhoushan) in Zhejiang province based on the field survey. Furthermore, factors affecting energy consumption of ORHs and RTHs are also analyzed. Main conclusions are as follows:

1) Energy consumption of RTHs is about 3 to 5 times higher than that of ORHs. Annual energy consumption of ORHs is about 9.54 GJ per capita in Quzhou, and 3.66 GJ per capita in Zhoushan. Annual energy consumption of RTHs is about 43.02 GJ per capita in Quzhou, and 18.71 GJ per capita in Zhoushan.

2) Non-commercial energy consumption of ORHs is high, while commercial energy consumption accounts for a small proportion. In these two areas, firewood accounts for 28.7% to 80.6%; electricity accounts for 8.6% to 36.6%; LPG accounts for 4.2% to 20.5%; solar energy accounts for 6.6% to 14.2%. In RTHs, firewood accounts for 59.9% to 66.7%; electricity accounts for 13.3% to 36.5%; LPG accounts for 8.2% to 31.3%; solar energy accounts for 11.5% to 32.3%.

3) EC for heating and cooling in RTHs is higher than ORHs, especially for cooling. In the two areas, EC for cooling in RTHs is about 24% to 39%. However, EC for heating and cooling in ORHs is very low, at about 13% to 16%. Cooking and hot water claim far higher energy in terminal energy consumption than others do, which take up about 75.1% to 93.7%, and 68% to 87.8% respectively.

4) Energy consumption of ORHs is affected by frequently used area, family

income level and permanent population. For RTHs, it is mainly related to the total building area, number of AC, number of guestrooms and family income level.

In a word, energy consumption of ORHs in Zhejiang rural areas is very low, which is achieved at the cost of comfort. In comparison, energy consumption of RTHs is higher, even higher than that of urban resident households. With the development of rural tourism industry in Zhejiang province, there will be more pressure in the future, and can't be ignored.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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