Advances in Social Science, Education and Humanities Research, Volume 496
Proceedings of the 2020 3rd International Conference on Humanities Education and Social Sciences (ICHESS 2020)

Analysis of the carbon neutrality capacity of household energy consumption in rural areas of Jiangxi Province

Zhenxu Zhang[1,2] Junsong Jia[1,2,*] Min Ju[1,2] Dongming Xie[3] Yangming Zhou[1,2]

[1]School of Geography and Environment, Jiangxi Normal University, Nanchang 330022, China
[2]Key Laboratory of Poyang Lake Wetland and Watershed Research, Ministry of Education, Jiangxi Normal University, Nanchang 330022, China
[3]Tourism College, Jiangxi Science & Technology Normal University, Nanchang 330013, China
[*]Corresponding author. Email: jiaaniu@jxnu.edu.cn; jiaaniu@126.com

ABSTRACT
In this study, we took Jiangxi's household energy consumption of rural areas as an example to analyze the carbon neutrality capacity by the Cao's assessment framework of carbon neutralization. Then, based on the gotten results, a scenario of considering the use of solar energy was designed for regional energy conservation, emission reduction and low-carbon development. Therefore, they have significantly theoretical value. The results are: the carbon neutrality capacity in rural Jiangxi experienced the three stages of full neutrality, static balance, and partial neutrality during 1990-2017, with the gradually increasing consumption of traditional fossil fuel. Moreover, for the second and third stages, full carbon neutrality can also be easily achieved only if the solar photovoltaic power is fully utilized.
Keywords: *Carbon neutrality, solar energy, biomass energy, traditional energy, Jiangxi*

1. INTRODUCTION

Carbon neutrality means zero carbon emissions or zero carbon footprint. On September 22, 2020, President Xi Jinping delivered an important speech at the general debate of the 75th United Nations General Assembly, stating that China will strive to peak at its carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060. So, it can be seen that carbon neutrality has entered into the international agenda. As a new force in China's development, rural areas have a lot of biomass fuels and clean energy, which can provide an impetus for rural economic growth, enhance energy security and improve the rural environment.

Many scholars have begun to focus on rural carbon neutrality levels. Chinese scholar Cao [1] first proposed an evaluation framework for carbon neutrality in rural areas and used the five-star classification system to reflect the carbon neutrality level. Lei [2] and others analyzed the carbon neutrality capacity of the Zhongguan region of Shaanxi Province. Liu [3] and others assessed the geographical distribution and potential of biomass energy sources in China, indicating the great potential for biomass energy development. Xing [4] evaluated the biomass energy source in Nantong, Jiangsu Province.

It can be seen that there are a lot of researches on the biomass energy and carbon neutrality capacity in China. However, most researches of carbon neutrality are only in one year, and there are few studies across time scales. Therefore, this paper takes the rural area of Jiangxi in the period of 1990-2017 as an example, examines its carbon neutrality level in depth, and proposes an effective way to strengthen the region's carbon neutrality capacity, which has an obviously innovative significance.

2. CARBON NEUTRALITY EVALUATION METHODS AND DATA SOURCES

2.1 Study Boundaries

The carbon neutrality analysis in this paper is mainly to compare the traditional fossil fuel use with the amount of renewable resources utilization in rural households sector of Jiangxi Province.

Household energy consumption mainly includes two aspects, direct and indirect domestic energy consumption [5]. Direct consumption includes commodity energy consumption such as coal, electricity and non-commodity energy consumption such as heating cooking and straw burning in rural areas; indirect energy consumption refers to the non-direct energy commodities and other services implicit in farmers' other life consumption throughout the life cycle. Indirect energy consumption has been entrenched in commodities and is difficult to analyze quantitatively, so in this study only the direct energy consumption of rural household is evaluated.

2.2 Carbon Neutrality Assessment

There are two computing ways of carbon neutrality capacity of energy use in rural household sector, namely carbon compensation and carbon offset, and each way has its direct and indirect methods. For the carbon compensation way, both direct and indirect methods are used to replace fossil energy sources such as coal to reduce the consumption of commercial energy. For carbon offset way, the direct method is to absorb carbon dioxide such as afforestation; the indirect method is to obtain a certain amount of carbon credit through the Clean Development Mechanism and so on. Considering the level of rural economic development and the abundance of biomass energy, the first method (carbon compensation) is more suitable and chose for the computation of the carbon neutralization capacity in this study.

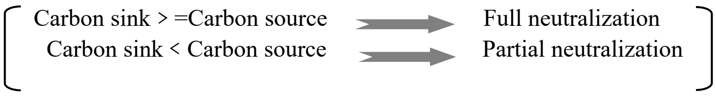

Figure 1 Cao’s Assessment Framework for the Carbon Neutrality Capacity

Based on Cao's carbon neutrality framework [1], carbon sources include commodity energy sources such as coal and electricity and non-commodity energy sources such as straw and firewood. Carbon sinks are mainly rural abundant biomass energy and clean energy. Biomass energy includes straw (deduct the amount used as fuel), human and livestock manure. Clean energy mainly includes wind, water and solar energy resources. Due to economic development and geographical constraints, only solar energy resources are computed. As shown in Figure 1, when the carbon sink is greater than or equal to the carbon source, it is fully neutralization, otherwise it is partial neutralization.

2.3. Data Sources and Computation Methods

In order to make carbon sources and sinks intuitively comparable, the unit of standard coal "tons" is unified. On the carbon source side, the calculation formulas of commercial energy and non-commercial energy are as follows:

$$EC = \sum_{i=1}^{n} e_i \cdot \beta_i \div 1000 \qquad (1)$$

Where EC is the per-capita energy consumption of the studied region. e_i is the per-capita energy consumption of i type. β_i is the energy coefficient, each coefficient is from the China Energy Statistical Yearbook. i is the energy type. On the carbon sink side, renewable energy includes various biomass resources and solar energy resources. Biomass energy sources mainly include crop straw resources, human and animal manure excretion. The amount of crop straw resources is related to crop yield, grass to grain ratio and energy coefficient. The collection coefficients are from Wang [6], Xing [4] and Cao [1] and shown in Table 1.

Table 1 Grass to grain ratios, Collection coefficients and Accounting factors for major crops：

	Rice	**Cotton**	**Oil**	**Hemp**	**Tobacco**
grass to grain ratio	1.1	3	2.63	1.9	0.7
Collection coefficient	0.87	0.89	0.85	0.87	0.9
Accounting coefficient	0.43	0.543	0.54	0.5	0.5

The calculation formulas of crop straw resources are as follows:

$$CR_e = \sum_{i=1}^{n} Q_i \cdot r_i \cdot f_i \cdot \lambda_i \cdot \eta_i \qquad (2)$$

Where CR_e is the per-capita amount of crop straw resources. Q_i is the crop yield, r_i is the crop grass to grain ratio, f_i is the straw collection coefficient, λ_i is the availability coefficient, η_i is the accounting coefficient of crop straw, and i is the crop type. Manure resources were estimated based on the daily manure production of different livestock. The collection coefficients and utilization rates of manure resources are from Liu [3] and Ma [7] and shown in Table 2. The calculation formulas of manure resources are as follows:

$$Q_3 = \sum Qd_i \cdot d_i \cdot m_i \cdot \eta_i \cdot \alpha_i \qquad (3)$$

Where Q_3 is the volume of livestock manure resources. Qd_i is the number of livestock , d_i is the daily excretion of livestock manure, m_i is the feeding period of livestock,

η_i is the factor of livestock manure, and α_i is the collection factor of livestock manure, and i is the livestock type.

Table 2 Manure excretion , Collection factors, and Accounting factors for humans and livestock:

	Human	Pigs	Cattle	Sheep	Rabbits	Poulty
Annual manure excretion /kg	30	280	1300	70	30	25
Collectible coefficient	1	1	0.6	0.6	1	0.6
Accounting coefficient	0.643	0.429	0.471	0.529	0.643	0.643

3. RESULTS AND DISCUSSION

By searching the statistical yearbook of Jiangxi Province, we can get the rural household energy consumption, crop yield and livestock quantity of Jiangxi province. By inputting these data into equations (1), (2) and (3), respectively, we can obtain the real results, which are shown in Figure 2.

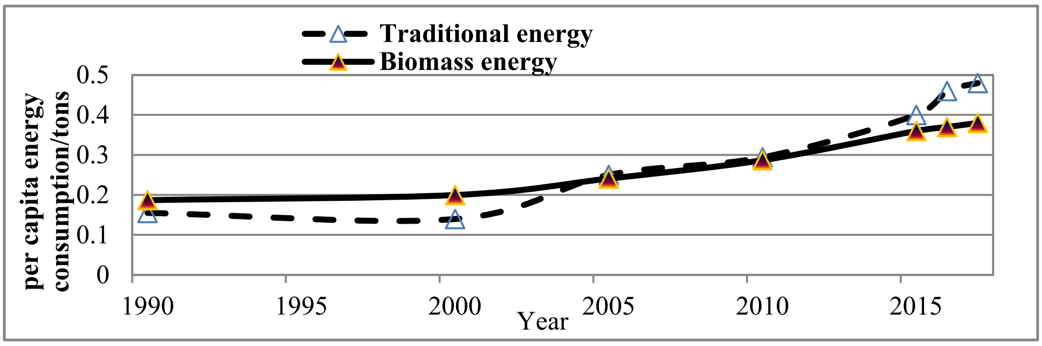

Figure 2 The per-capita energy consumption in rural areas of Jiangxi Province in reality

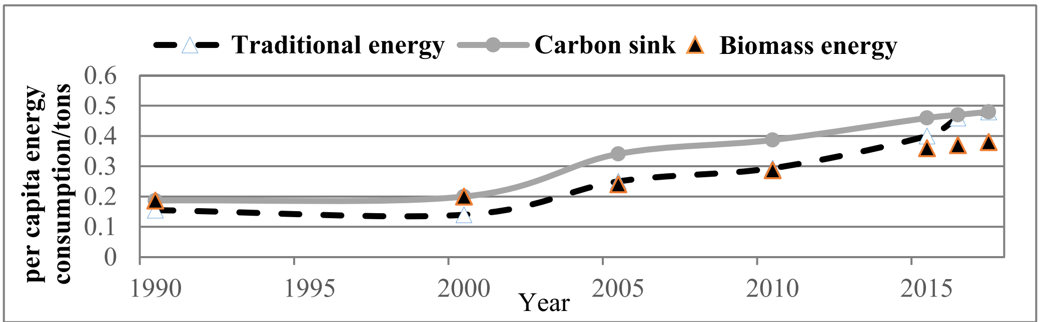

Figure 3 The per-capita energy consumption in rural Jiangxi in the scenario of considering the use of solar photovoltaic

As shown in Figure 2, the per-capita biomass energy in rural areas of Jiangxi province had a continuous increase from 1990 to 2017, with an average annual increase of 0.7 %. However, the traditional energy had in the decline trend from 1990 to 2000; inversely, it had a growth change from 2000 to 2017, with an average annual growth rate of 1.2%. So, it can be easily seen that the carbon neutrality capacity of rural areas in Jiangxi province was full neutralization in 1990-2005. This is because people relatively low-efficient utilized the biomass energy (straw and manure resources) in this period(1990-2005). At the same time, the energy consumption (fossil fuel) was rarely used due to the traditional life habits. Biomass energy is more abundant than traditional energy sources.

Then, the fast development of agricultural technology in rural Jiangxi and the use of chemical fertilizers brought higher crop straw yields in 2005-2017. Meanwhile, state restrictions' policy on straw burning and the promotion plan of biomass energy contributed to the rapid growth of biomass energy. Therefore, the average annual growth rate of the biomass energy reached was 1.2% in this period. However, traditional energy consumption increased faster and faster with the acceleration of rural economy, implementation of central rising strategy and modernization of agriculture. The average annual growth rate of the traditional energy reached 1.4% (> 1.2%). Thus, the carbon neutrality capacity was basically static balance in the second stage (2005-2010) and partially neutralized in the third stage (2010-2017).

Now, let us imagine this scenario of considering the high-efficient use of solar photovoltaic (PV). The method of PV power generation is from Lei [2] and as follows:

$$RE = WH \times \beta_d = WP \times H \times \beta_d \div 1000 \quad (4)$$

Where RE is the per-capita renewable energy resources, WH is the photovoltaic panel power generation (kW • h), WP is the peak solar panel power, H is the peak sunshine hours in the sample area, and β_d is energy accounting factor. The average annual sunshine hours in Jiangxi Province is about 1473-2077 hours, where the mean value of 1775 hours is used.

As shown in Figure 2 , the per-capita consumption of traditional energy is 0.48 tons and the per-capita use of biomass energy is 0.38 tons in rural Jiangxi in 2017. Therefore, the state of full carbon neutrality can be easily achieved only by adding a per-capita 0.10 tons amount of solar PV into the biomass energy in this region in 2017. Supposing that with the development of economy and the popularity of low carbon concept, people began to exploit and utilize the solar energy early in 2005. Namely, the per-capita 0.1 tons of solar PV can be ideally added to the biomass energy from that year. Correspondingly, the carbon sink results of rural Jiangxi are plotted in the solid gray line and shown in Figure 3. These results indicated that the full carbon neutrality can be easily achieved in the stages 2 and 3 (2005-2017) and also be in the whole studied period (Figure 3).

4. CONCLUSION

Taking Jiangxi’s household energy consumption of rural areas as an example, we analyzed the carbon neutrality capacity by the Cao’s assessment framework of carbon neutralization. The results showed that the carbon neutrality capacity in rural Jiangxi experienced the three stages of full neutrality (1990-2005), static balance (2005-2010), and partial neutrality (2010-2017) during the studied period. The reason of the change from full neutrality to partial neutrality was that people used more and more traditional fossil fuel. So, we designed a scenario of considering the use of solar photovoltaic powder for this region from 2005, and found that full carbon neutrality in the whole studied period can also be easily achieved only if the solar photovoltaic power is fully utilized.

ACKNOWLEDGMENT

We are very grateful for the financial support provided by the Research Project of Humanities and Social Sciences in Jiangxi’s Universities (Grant No. GL19225) and Chinese National Science Foundation (Grant No. 71473113).

REFERENCES

[1] S.Y. Cao, T.T. Huo, Evaluation of rural household carbon neutrality in energy consumption, China population, resources and environment. 24(2014):301-303. DOI: http://doi: CNKI: SUN: ZGRZ.0.2014-S3-075 (in Chinese)

[2] X.M. Lei, J.J. He, S.B. Yang, Feasibility and environmental protection of "zero-carbon village" from the perspective of energy transformation-- Take F Village, C County, Guanzhong, Shaanxi as an example, Journal of Beijing Institute of Technology (Social Science edition). 22(5) (2020): 32-41 DOI: http;//doi:10.15918/j.jbitss1009-3370.2020.3300 (in Chinese)

[3] G. Liu, L. Sheng, Quantitive Appraisal of Biomass Energy and Its Geographical Distribution in China, Journal of Natural Resources. 22(1) (2007): 9-19. DOI: http:/doi:10.3321/j.issn:1000-3037.2007.01.002.(in Chinese)

[4] H. Xing, Y. Zhao, Y.Q. Wang, Estimate and distribution of rural biomass resource potential in Nantong City Jiangsu Province, Acta ecologica sinica. 35(10) (2015) :3480-3489. DOI: http://doi:10.5846/stxb201307071855 (in Cinese)

[5]Y.M. Li, L. Zhang, Structural Decomposition Analysis of China's Indirect Household Energy Consumption, Resources science. 30(6) (2008): 890-895. DOI：http://doi:10.3321/j.issn: 1007-7588. 2008.06.014 (in Chinese)

[6]T. Wang, X.J. Chang, Z.H. Huang, Estimation of Main Crop Straw Resources and Analysis of Energy Potential in Xi'an, Journal of Anhui Agri. 45(16) (2017) 73-77. DOI: http: //doi:10.3969/j.issn.0517-6611. 2017.16. 023 (in Chinese)

[7] Z.Q. Ma, Y.Y. Zhu, T. Hong, Analysis of the Present Condition and Recommendations on Biomass Energy Industry Development in Jiangsu Province, Chinese Soft Science. 0(10) (2008) 65-72. DOI: http://doi:10.3969/j.issn.1002-9753.2008.10.009 (in Chinese)