Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 7, No. 2, 2023

Analysis of Influencing Factors of Rural Residential Carbon Emissions Under the Background of Dual Carbon Target

Yang Li, Wenyan Zhang, Weiwei Zhang

College of Civil and Architectural Engineering, North China University of Science and Technology, Tangshan, 063210, China

Abstract: This paper studies the carbon emission of rural residential buildings under the background of ' double carbon target '. Based on the characteristics of rural residential buildings and the current situation of carbon emission, the literature research method is used to identify the residential characteristics, enclosure structure, family situation, lifestyle, energy consumption equipment, renewable energy utilization and agricultural production function. The carbon emission influencing factors of 21 rural residential buildings in the use stage of rural residential buildings are helpful to evaluate the carbon emission of buildings more accurately, provide the basis for formulating carbon emission reduction strategies, and promote the sustainable development of rural residential buildings. It is of great significance.

Keywords: Rural residential building, Carbon emission, Influencing factor,' Double carbon target '.

1. Introduction

In the context of the dual-carbon goal, low-carbon buildings have become a key issue for global sustainable development. The carbon emissions generated in the construction field account for about 50 % of the total, and the carbon emissions in the construction operation stage are the largest in the construction life cycle [1]. As an important place for the production and life of rural residents, rural residential buildings are the main energy consumption body, and play an important role in realizing the " double carbon " goal and promoting the construction of new countryside. At present, most of China 's rural residential buildings are mainly brick-concrete structures and reinforced concrete structures. According to the current situation of rural residential buildings, it can be seen that the carbon emissions generated by poor thermal insulation performance and large energy consumption of rural residential buildings have seriously hindered the development of low-carbon buildings.

Therefore, based on the characteristics of rural residential buildings and the current situation of carbon emissions, the literature research method is used to analyze and identify the influencing factors of carbon emissions of rural residential buildings under the background of double carbon, so as to provide the basis for index accounting for carbon accounting of rural residential buildings and provide scientific basis for low-carbon rural residential building construction.

2. Identification of Influencing Factors of Carbon Emissions in The Use Stage of Rural Residential Buildings

The preliminary extraction of the influencing factors is the first step in the identification of the influencing factors of carbon emissions in rural residential buildings. The literature research method is used to extract, and the keywords such as ' rural residential buildings ', ' building carbon emissions ', ' carbon emission influencing factors ', ' low-carbon buildings ', etc.are searched on the paper data platform. Search for relevant doctoral and master 's papers and journals, select more citations, elaborate more comprehensive literature 10 articles, organize and read the literature, conduct a preliminary identification of the influencing factors of carbon emissions, and form the original list of influencing factors of carbon emissions in rural residential buildings, see table 1.

3. Extraction and Analysis of Influencing Factors

Through the extraction of the influencing factors of carbon emissions and the summary of the existing research results, the preliminary extraction of the influencing factors is completed. On this basis, considering the development status and characteristics of rural residential buildings, the above summary factors are divided into seven levels:

(1) Residential characteristic factors

The larger the rural residential building area is, the more energy is needed to meet the needs of heating, lighting, refrigeration and so on. When heating in winter and cooling in summer, more heating or cooling equipment is needed, and the use of more energy will directly lead to an increase in carbon emissions. The building age determines the use of residential building structure, building materials, equipment and technology. Rural houses with long construction years usually lack the use of thermal insulation materials and energy-saving equipment. In particular, old equipment has low energy efficiency and faces the problems of equipment aging and poor maintenance, resulting in waste of energy and increase of carbon emissions. Building orientation has an impact on the carbon emission level of rural houses by affecting solar energy utilization and natural ventilation. The building shape is standardized and the direction of the sun can be installed in the direction of solar photovoltaic panels and other equipment to produce clean energy. At the same time, the south-facing windows capture more sunlight for heating in winter and reduce dependence on the heating system. On the contrary, north-facing buildings may require more heating and cooling equipment to regulate indoor temperature, resulting in higher carbon emissions. The influencing factors of residential characteristics are shown in Table 2.

Table 1. The original list of factors affecting carbon emissions from rural residential buildings

serial number	scholar	published time	residential type	influencing factor
1	KELLY S[2]	2011	urban dwelling	number of households, building area, household income, living efficiency, household heating mode and living room temperature.
2	Xuyan Ning [3]	2013	rural residential building	heating status, per capita income, residential area, resident population, cooking type, cooling status, number of electrical appliances, domestic hot water situation
3	Qin Yang [4]	2015	urban residential building	building characteristics, family socio-economic characteristics, heating methods, indoor temperature evaluation, energy saving awareness
4	HUEBNER G M[5]	2015	urban dwelling	building area, building type, family characteristics, occupant behavior, heating behavior.
5	Kaiwen Wang [6]	2020	rural residential building	resident population, personnel structure, household income, construction area, number of household appliances and use of solar and biomass energy.
6	KHAKIAN R[7]	2020	rural residential building	building orientation, window-wall ratio, glass type, sunshade and thermal insulation
7	Fangwei Zhu [8]	2021	urban residential building	household population, building area, building type, building age, building floor, building envelope, summer air conditioning form, winter heating form, domestic hot water source form, main equipment quantity, energy consumption type and energy consumption
8	Yifan Wang [9]	2021	urban residential building	house form
9	Qinzhu Wng [10]	2021	urban dwelling	basic family situation, residential indoor condition, residential building design, daily behavior consciousness, family per capita annual income, air conditioning temperature, housing area, building shape coefficient, green space rate, layout form, building density.
10	Longshu Hou [11]	2022	rural residential building	clean heating

Table 2. The influencing factors of rural residential carbon emissions at the level of residential characteristics

Category	Serial number	Factor name
Residential characteristic factors	M_1	Building area
	M_2	Building age
	M_3	Building orientation and shape

(2) Enclosure structure factors

A good rural residential building envelope structure can reduce the temperature difference between indoor and outdoor, prevent outdoor heat from entering too fast in summer, avoid direct entry of cold air in winter, reduce heating and cooling demand, reduce building energy loss, improve energy efficiency, and reduce carbon emissions. The window wall ratio is larger than the high equivalent window area, and the indoor heat is transmitted through the window to the outdoor faster, resulting in increased energy consumption and carbon emissions. The lower window-to-wall ratio can reduce heat conduction and reduce energy consumption. The high window-to-wall ratio means that more natural light enters the room, reducing the demand for artificial lighting and reducing consumption and carbon emissions. Different building materials have different thermal conductivity and thermal insulation properties. The materials used in the construction of roofs, grounds, and windows directly affect the carbon emissions of rural houses. The use of better thermal insulation materials can reduce the use of cooling and heating equipment, and more durable materials can reduce the frequency of building maintenance and renovation, thereby reducing energy consumption and carbon emissions. The influencing factors of the enclosure structure level are shown in table 3.

Table 3. Influencing factors of rural residential carbon emissions at the enclosure structure level

Category	Serial number	Factor name
Enclosure structure factors	M_4	Thermal insulation effect of envelope structure
	M_5	Window-wall ratio
	M_6	Building material

(3) Family factors

Due to the rapid development of society, a large number of rural population into the city, and the population is uncertain. A large family resident population usually requires more energy demand such as electricity, lighting, heating, and cooling. Under the same conditions, a family with more family members consumes more energy in washing, bathing, cooking, and using electrical appliances, and the amount of energy consumption leads to an increase in carbon emissions. Different household incomes have different effects on carbon emissions. Households with higher income levels, living standards and consumer demand increase, the number of appliances and the use of time may increase, resulting in more electricity use. However, families with high income levels generally have more flexible choices of housing conditions and building materials. Choosing high-quality building materials and efficient heat insulation facilities can reduce energy consumption and reduce carbon emissions. With the popularization of education, the education level of rural households has generally improved. Families with higher education levels may pay more attention to family living habits, the choice of low-energy household equipment, environmental protection and sustainable living awareness, and are willing to adopt energy-saving and emission reduction measures to reduce carbon emissions. The influencing factors of family situation are shown in table 4.

Table 4. The influencing factors of rural residential carbon emissions at the household level

Category	Serial number	Factor name
Family factors	M_7	Number of permanent household population
	M_8	Household per capita income
	M_9	The highest educational level of the family resident population

(4) Lifestyle factors

The cooking method of rural residential buildings has the traditional cooking method of using coal and firewood, which has low combustion efficiency and produces more carbon emissions. The high combustion efficiency of clean combustion technologies such as coal to gas and coal to electricity can reduce the emission of harmful gases and particulate matter and reduce carbon emissions. The choice of cooking utensils will also affect energy consumption and carbon emissions. Traditional cooking utensils have low efficiency and large heat loss, resulting in energy waste and increased carbon emissions. Summer cooling methods generally include electric fans, air conditioners, etc. Reasonable architectural design, building materials, good heat insulation and shading measures, ventilation optimization can reduce indoor temperature rise, reduce dependence on cooling equipment, thereby reducing energy consumption and carbon emissions.

In winter heating, the kang and coal heating with straw and coal as fuel are generally used, and the gas-fired wall-mounted furnace with natural gas as raw material is widely used in rural areas. In a few winters, electricity and natural gas are mixed for heating ; traditional rural commonly used fuels include coal, straw, etc. Different heating methods use different energy sources, and the combustion of different energy sources will produce different levels of carbon emissions. The use of fossil fuels such as coal for heating will produce higher carbon emissions. With the improvement of rural power grids, rural areas are more likely to use electric heating methods, which are easy to use, clean and pollution-free. The population in rural areas mainly includes the elderly and children. There is a general lack of low-carbon and energy-saving knowledge, and there are still high-carbon emission behaviors such as burning coal for heating.

Regional climate characteristics can directly affect the heating and cooling needs of rural residential buildings, energy use types, building characteristics, and the use of electrical equipment. Residential buildings in cold regions need better thermal insulation measures and thermal insulation materials ; residential buildings in hot areas need to use more energy to cool down ; under specific climatic conditions, rural residents may be more inclined to choose energy-saving technologies and equipment adapted to the local climate, and different needs lead to increased energy consumption and carbon emissions. The influencing factors of lifestyle level are shown in table 5.

Table 5. Influence factors of rural residential carbon emissions on lifestyle level

Category	Serial number	Factor name
Lifestyle factors	M_{10}	Cooking way
	M_{11}	Cooling methods
	M_{12}	Heating system
	M_{13}	Energy Saving and Low Carbon Awareness
	M_{14}	Regional climate characteristics

(5) Energy consumption equipment factors

The carbon emission of terminal energy consumption appliances in the use stage of rural residential buildings mainly comes from the common energy consumption of heating, refrigeration, refrigerator, domestic hot water, lighting and so on. Different rural houses have different types of electrical appliances and electrical power requirements. In some rural areas, the energy efficiency of terminal energy-consuming appliances may be low, and the same function requires more energy. With the increase of equipment use

time, the equipment is prone to aging, especially in rural areas, the renewal speed of electrical equipment is relatively slow, the operation efficiency is low, and the energy consumption is higher than that of new equipment under the same working effect. In addition, rural houses can reduce the demand for traditional energy such as coal and have an impact on carbon emissions by strengthening thermal insulation, improving lighting conditions, optimizing heating and cooling methods and other measures for energy-saving transformation. The influencing factors of energy consumption equipment level are shown in table 6.

Table 6. Influencing factors of carbon emissions from rural residential buildings at the level of energy consumption equipment

Category	Serial number	Factor name
Energy consumption equipment factors	M_{15}	Type of residential electrical appliances
	M_{16}	The use of residential terminal energy consumption electrical appliances
	M_{17}	New building energy-saving renovation

(6) Renewable energy utilization factors

Rural residential buildings usually use traditional energy as the main source of energy, but the carbon emissions are higher when traditional energy is used. In rural areas with a high degree of electrification, energy supply depends on electricity, and residential energy consumption is generally generated by indoor electrical equipment. Electricity usually comes from clean energy such as renewable energy or nuclear energy, and the carbon emissions generated during use are low. Clean energy mainly includes renewable energy sources such as solar energy, wind energy, and hydraulic energy. The carbon emissions generated during use are low or even zero. The use of clean energy as an energy source can significantly reduce carbon emissions in rural residential use. The influencing factors of renewable energy utilization level are shown in table 7.

Table 7. Influencing factors of carbon emissions from rural residential buildings at the level of renewable energy utilization

Category	Serial number	Factor name
Renewable energy utilization factors	M_{18}	Degree of electrification
	M_{19}	Clean Energy Use

(7) Functional factors of agricultural production

In the use stage of rural residential buildings, according to the actual needs and living habits of family members, reasonable design of courtyard use planning can optimize the building layout and make full use of resources. Maximize the use of solar energy and reduce the demand for other energy sources. Reasonable planning of the vegetation in the courtyard, providing a cool and cool effect, reducing the demand for air conditioning, energy consumption and carbon emissions will be lower. Household production activities will produce a certain amount of waste, such as agricultural waste, livestock and poultry manure, processing waste, etc., and the treatment of waste may lead to carbon emissions. The influencing factors of agricultural production function level are shown in table 8.

Table 8. The influencing factors of carbon emissions from rural residential buildings at the level of agricultural production function

Category	Serial number	Factor name
Functional factors of agricultural production	M_{20}	Courtyard use planning
	M_{21}	Household production

4. Conclusion

This study reviews the literature on the influencing factors of carbon emissions in rural residential buildings through the literature research method, and summarizes the scattered factors into seven levels : residential characteristics, envelope structure, family situation, lifestyle, energy consumption equipment, renewable energy utilization, and agricultural production functions. The comprehensive analysis of the factors identified 21 influencing factors, and the following conclusions were drawn :

(1) Through the analysis of the current situation of rural residential buildings, it is found that the current rural residential buildings have high energy consumption and high carbon emissions, and the scale of energy-saving transformation and popularization still needs to be improved. It is important and necessary to promote the development of low-carbon rural residential buildings.

(2) The characteristic factors of rural residential buildings have a significant impact on carbon emissions. Enclosure structure factors play an important role in reducing carbon emissions of rural residential buildings. Family factors and lifestyle factors have a great impact on the carbon emissions of rural residential buildings. Energy consumption equipment factor is one of the key factors of rural residential building carbon emissions. Renewable energy utilization factors have potential in carbon emissions from rural residential buildings. The factors of agricultural production function also have a certain impact on the carbon emissions of rural residential buildings.

In summary, by comprehensively considering the influencing factors of carbon emissions in rural residential buildings and formulating corresponding development and impact strategies, it can effectively reduce the carbon emissions of rural residential buildings and provide important support for achieving the dual carbon goal. Future research can further explore the weight of each factor and the relationship between them, and explore more specific policies

and measures to achieve sustainable development and carbon emission reduction targets in rural residential building construction.

References

[1] Building Energy Efficiency Research Center of Tsinghua University. Annual Development Report of Building Energy Efficiency in China[M]. Beijing: China Building Industry Press. 2023.

[2] Kelly S. Do homes that are more energy efficient consume less energy: A structural equation model of the English residential sector[J]. Energy, 2011, 36(9): 5610-5620.

[3] Xuyan Ning, Xu Zhang, Jun Gao. Analysis of the current situation and influencing factors of domestic energy use in typical villages and towns in different climate zones[J]. Architectural Science, 2013, 29(12): 98-102.

[4] Qin Yang, Qunying Cheng, Xuewei Yu, et all. Study on the current situation of residential heating and the influencing factors of carbon emissions in Guiyang[J]. Gas and heat, 2015, 35(03): 33-37.

[5] Huebner GM, Hamilton I, Chalabi Z, et all. Explaining domestic energy consumption-the comparative contribution of building factors, socio-demographics, behaviours and attitudes[J]. Applied energy, 2015, 159: 589-600.

[6] Kaiwen Wang, Chuanyue Sun, Zhijia Huang. Analysis of energy consumption status and influencing factors of rural residential buildings in Ma 'anshan City[J]. Building thermal energy ventilation and air conditioning, 2020, 39(10): 52-56.

[7] Khakian R, Karimimoshaver M, Aram F, et al. Modeling nearly zero energy buildings for sustainable development in rural areas[J]. Energies, 2020, 13(10): 2593.

[8] Fangwei Zhu, Chunzhi Zhang, Min Chen, et all. Carbon emission analysis and total accounting of urban residential buildings in Wuhan[J]. Building energy efficiency (Chinese and English), 2021, 49(02): 25-29.

[9] Yifan Wang, Xue Li, Dachang Yuan. Research on the correlation between residential form and carbon emissions-Taking Jintang County as an example[J]. Building energy efficiency (Chinese and English), 2021, 49(09): 155-160.

[10] Xinzhu Wang, Jianqiang Wang, Shanwen Zheng. Research on the impact mechanism of carbon emissions in residential areas and carbon reduction planning strategies-Taking Jiujiang City as an example[J]. Central China Architecture, 2021, 39(03): 44-50.

[11] Longshu Hou, Hongtao Ding, Shanshan Wang. Evaluation of the impact of clean heating on carbon emissions in rural residential areas[J]. Building Science, 2022, 38(12): 260-265.