

Analysis on energy-saving path of rural buildings in hot summer and cold winter zone

Mingqiang Huang and Jinheng Li ¹

School of Civil Engineering & Architecture, Xiamen University of Technology,
Xiamen, 361024, China.

¹ 1477584230@qq.com

Abstract. Since the reform and opening policy, the construction of rural area in China has become more and more important. The idea of establishing green villages needs to be accepted and recognized by the public. The hot summer and cold winter zone combines two contradictory weather conditions that is cold winter and hot summer. So the living conditions are limited. In response to this climate, residents extensively use electric heaters or air conditioning to adjust the indoor temperature, resulting in energy waste and environmental pollution. In order to improve the living conditions of residents, rural area energy conservation has been put on the agenda. Based on the present situation and energy consumption analysis of the rural buildings in the hot summer and cold winter zone, this article puts forward several energy saving paths from government, construction technology and so on

1. Introduction

China has 1.3 billion people, of which 900 million in rural areas, rural construction covers an area of more than 10 times than the city [1]. The current social situation is the energy shortage, energy conservation has become an eternal topic. In the construction industry, according to the *"thirteen five" plan of building energy saving and green building development* published by the Ministry of Housing and Urban-Rural Development of the People's Republic of China, we should now promote rural building energy efficiency actively, and guide the construction of energy-saving green buildings. Encourage the residents build their houses depending on the *Design standard for energy efficiency of rural residential buildings (GB/T50824)*. Strengthen the skills of rural construction teams, instilling the awareness of energy conservation.

China's land area of total land is about 9.6 million square kilometers, accounting for the world's total land area of 1/15, and the diverse types of climate divided into extreme cold zone, cold zone, hot summer and cold winter zone, hot summer and warm winter zone and warm zone. The hot summer and cold winter zone are the transitional regions of cold zone and hot summer and warm winter zone. China's hot summer and cold winter zone spans 15 provinces, municipalities and autonomous regions, regional economy is very important. Because the weather in this region is hot in summer and cold in winter, belonging to two contradictory climate, the selection and application of green building technology are difficult and complex.



2. Analysis on the building construction and energy consumption of rural areas in hot summer and cold winter zone

2.1. The division of hot summer and cold winter zone

The hot summer and cold winter zone is a specific areas which is divided depending on the index of the coldest month and the hottest month average temperature and the annual average temperature, to distinguish the difference of the climatic conditions on the buildings in different areas. It located at the middle and lower reaches of the Yangtze River, the area is about 1.8 million km², and the population of these areas is about 550 million. Including the two municipalities of Chongqing and Shanghai; five provinces of Hubei, Hunan, Anhui, Jiangxi and Zhejiang; the east of Sichuan and Guizhou provinces; the south of Shanxi, Henan, Jiangsu provinces; the north of Guangxi, Guangdong, Fujian provinces, involving total 15 provinces, municipalities and autonomous regions. The hot summer and cold winter zone is hot in summer and the winter is cold and humid. Annual hot season has 3-4 months, the hottest month indoor average temperature up to 30-33°C, summer relative humidity is about 80%, solar radiation is greater than 1000MJ/m². Annual cold season has 2-3 months, the coldest month indoor average temperature is only 0-6 °C, and the solar radiation in winter is less than 750 MJ/m² [2]. The region's annual period of using heating and air conditioning is longer than other area, thus, the energy consumption is also higher. Therefore, to save the energy of residential buildings in these areas not only need to consider the heat preservation in winter, but also need to lower the temperature in summer, and the ventilation in spring and autumn is also important [3].

2.2. The building construction status of rural areas in hot summer and cold winter zone

Since the reform and opening policy, the pace of development and construction of rural areas have been accelerated. With the continuous improvement of economic conditions, the residents of rural areas are constantly improving their living conditions. At present, the construction of rural areas in China is characterized by taking up a lot of land with a large amount of houses. The design of these houses has no standard, and the main types of residential houses are self-built small houses, the other centralized residence are constructed by the government, they belong to the new rural construction, but this type of residence is the minority. There are no management or the management system exist in the majority of self-build independent small houses, these houses still have many defect. First of all, the self-built construction generally don't have architects to participate in the design, the residents often plagiarize each other's design and compare with each other. Due to the lack of building energy conservation concept, self-built houses often waste the energy and money, the building qualities have no guarantee. For instance, because of the lack of pre-geological exploration, the building has an unstable foundation lead to a poor resistance to disaster, it's a waste of resources and money. Second, the contractors of such projects are mostly individual woodworking workers and other combinations of no-name team, they didn't receive formal training and didn't familiar with all kinds of criterions, the backward construction technology, the materials' selection is not strict, so the cost of building the houses is high. Therefore, publicizing the concept of green building actively is important, and it's necessary to sum up a set of practical program to reduce the energy consumption in rural areas.

2.3. Analysis on energy consumption of villages and towns in hot summer and cold winter zone

For a long time, China's rural life is based on bio-energy. The fuel relies mainly on firewood, crop straw or coal. The burning of these fuels is a waste of resources and it will pollute the environment. Hot summer and warm winter zone has a cold winter and hot summer, so the high-efficient heating and a good ventilation and lighting are indispensable, but the walls, roofs, doors and windows are still use the traditional crafts, the enclosure of rural house has a poor Insulation performance, the energy consumption is high, and the burning of fuel will be a security risk. In the summer, if the area of lighting is too large it will cause the poor ventilation, residents always use fan or air conditioning to lower the temperature will also cause energy waste.

According to the *China Building Energy Conservation Annual Development Research Report (2015)* (Tsinghua University Building Energy Research Center) data shows that nearly a decade, China's civil construction energy consumption accounted for the proportion of the total energy consumption has been maintained at 20% -25%, The total energy consumption of China's construction in 2013 is as high as 756 million tons of standard coal, accounting for 19.50% of the total energy consumption. In 2013, the rural residential construction area is 23.8 billion square meters, accounting for 44% of the total construction area of the country. Building energy consumption was a sharp upward trend with the rising number of total construction and the people's desire of comfortable living. With the rapid development of China's economy, urbanization, industrialization and resident living standards, the requirements of building comfort have become highly increasing, the use of heating and air conditioning become more and more common, the increasing number of household appliances. The lighting conditions gradually improved, also resulting in a rapid increase in building energy consumption.

The structure of rural building's wall in hot summer and cold winter zone generally has no insulated measures, and most house use brick and concrete structure. The outer wall are mostly use 240mm thick ordinary solid clay brick, paint the cement mortar or use ceramic tiles on both sides of wall, so that the thermal resistance is very small. The roof is generally made of sloping roof or flat roof, the roof mostly use 120mm thick hollow board for the structural layer or directly use concrete, the structure is very simple, only few roofs have insulated layer or ventilated layer. Most of the windows are Single-layer glass push-pull aluminum alloy window, air-tightness and water-tightness is poor. The whole building is hot in summer and cold in winter, so the residents need more air condition, electric heaters and other equipment to keep the indoor environment warm, resulting in a great waste of energy.

3. The energy-saving paths in hot summer and cold winter zone

3.1. The government

(1) Popularize the criterion of *Design standard for energy efficiency of residential buildings in hot summer and cold winter zone (JGJ134-2001)*, and the green building energy conservation knowledge. Constitute the inspection team, inspect the substandard local buildings, and the government suggest to destroy the substandard buildings and provide centralized residence.

(2) Reasonable planning the spacing between the rural houses, build two or more houses in parallel, the structure of buildings should be simple and regular, reduce the building main part's size, improve the land utilization rate.

(3) Establishment of incentive mechanism. The government can set the incentive mechanism within the rural area, the residents who can actively cooperate with the government rectification can get the subsidization and some other preferential policies.

(4) Strengthen the Green Building

Greening can bring great improvement to the rural environment, and prevent all the land turn into arable land. After consider the overall situation the government should plan the green belt, reduce the over-pollution of burning firewood, crop straw or coal. Second, the greening design in the summer can strengthen the ventilation, it can also help to reduce the natural light of the glare in the summer, provide the natural green shade. In the winter, it can also block the cold wind, protect the building directly, minimize the energy that cooling and heating equipment use. In general, greening can effectively improve the building microclimate.

3.2. Natural ventilation

The good natural ventilation is the best way to adjust the climate in hot summer and cold winter zone. The use of passive energy-saving concept can make the indoor space's temperature suitable for people, well ventilated, so that people can use heating and air conditioning equipment to adjust the indoor

temperature only in the summer and winter extreme weather conditions, making the whole year achieve a good environment.

Good natural ventilation can lower the air conditioning energy consumption. In order to expand the comfort area in hot summer and cold winter zone can strengthen the natural ventilation, the natural ventilation can extend the transition season, and the generally acceptable temperature limit is 30°C-31°C. Make full use of wind pressure ventilation to improve indoor temperature must be established in the suitable external wind environment. In order to ensure the wind, you must set the ventilator on both sides of the building [4]. The large depth room or the bottom of the space generally has a poor ventilation, so the external wind environment is not appropriate, we should use hot pressure ventilation to promote natural ventilation. Chimneys can promote the natural ventilation of half height of the chimney's house, improve the neutral position of the chimney can improve the ventilation of all the rooms. In general, to achieve the similar wind and improve the capacity of the chimney, we can expansion the total area of air outlet and the solar energy can provide stable heat source on the top of the chimney [4].

3.3. Construction technology and materials

3.3.1. Wall. The key point of wall construction and energy conservation is heat preservation, because of the characteristics of hot summer and cold winter zone, the wall insulation needs to be handle on both sides of the wall. We can change 240mm thick brick wall to 370 mm thick brick wall, this can lower the heat output of the external wall, and this approach is the most simple, and the cost is low, so that residents can easily accept it. We can also change the material, the choice of gangue porous brick (size 240mm×240mm×115mm), its thermal conductivity is 0.45, and the aperture of brick filled with 50mm thick expansion polystyrene board, the thermal conductivity is 0.21. If the double-sides painting wall is used, the heat transfer coefficient of the wall is $K \leq 0.75 \text{ W}/(\text{m}^2 \cdot \text{K})$, which can meet the thermal performance requirements of the external walls of the living buildings in the hot and cold winter zone. The layer of self-built residential buildings always below 3[5].

3.3.2. Outside window. The windows need to consider the ventilation, sunshine, light transmission and other functional requirements, in addition, as a part of the exterior-protected construction, windows also need to play a role of thermal insulation. In the summer, according to the general statistics, the heat through the window account for 20%-30% of the maximum load of air condition, in the winter, single-layer glass heat loss of about 30% -50% of the heating load [6], so the window is the important and weak links in rural building insulation and energy conservation. The construction of the external window should be considered to meet the lighting needs, but it should be noted that the big windows are too detrimental to the building insulation, so the window wall should achieve the request of *Design standard for energy efficiency of residential buildings in hot summer and cold winter zone (JGJ134-2001)*. Rural residential windows generally use double-layer aluminium-plastic windows and steel-plastic windows because of the better thermal insulation performance. Residents are now commonly use ordinary single-layer glass, the thermal resistance is very low, and in the winter or summer, the glass inside and outside have large temperature difference, it's easy to produce condensation. We can also glue more than 2cm thick transparent plastic film on the inside window, forming an air layer, so that the heat loss less.

3.3.3. Roofing. The current roof of the rural area is divided into flat roof and slope roof, relatively speaking, the slope roof insulation performance is better than flat roof, and water resistance is also better. Thin flat roof easily loss energy, so we can choose to set the more than 120mm thick expansion perlite on the roof structure, this material is easy to get and cheap, it can also play a very good insulation effect, and residents can accept it at the same time. The other choice is change flat roof to slope roof, and in the inside of the roof add insulation layer, this can not only improving the insulation effect, but also make full use of the slope of the ideal thermal buffer to set the ventilation layer.

3.4. Biogas utilization

Biogas is the most promising renewable energy in rural areas, can be used for cooking, lighting, heating, etc. Biogas flotsam can also be used for fertilizer. Based on the poor performance of housing insulation, based on the transformation of indoor heat preservation, support the low-emission energy-saving heating and commercial water-warm bed, so that we can promote the formation of energy-saving and low-emission mode in rural area. If the residents set up an independent biogas digesters, the biogas tank should be built beside greenhouse and pigsty to avoid the influence of low temperature, because the low temperature will make the biogas difficult to ferment. If the promotion of biogas tank is successful, we can form a big centralized biogas tank in the rural area, and that will be more convenient. Biogas residue and the excess biogas slurry can use to irrigate the surrounding farmland, rational use the resources.

4. Conclusions

China's hot summer and cold winter zone covers a wide area, of which the rural houses occupy most of the land. The development of energy-saving building construction has a huge potential, if the village can develop energy-saving building into scale, the distribution for China's green building market is vital. Since the hot summer and cold winter zone has its own contradictory climate, this climatic conditions increase the difficulty of rural residential energy-saving construction. It is a systematic project of rural residential energy-saving construction, we need to consider all aspects of the impact based on controlling costs and operating simply, indeed improve the quality of life of rural residents and save energy.

Acknowledgment

This research was supported by the National Natural Science Foundation of China (NSFC) (Grant No. 71503224) and Fujian Social Natural Science Foundation (Grant No. FJ2015C110). The work described in this paper was also funded by Fujian Province Middle and Young Teacher Education Research Program (Grant No. JA15374) and the Program for High Level Talents in Xiamen University of Technology (Grant No. YKJ4024R).

References

- [1] Hua J J, Zhang L H, Li Y W 2010 Research on residential energy saving in the construction of new socialist countryside [J] *Journal of Anhui Agricultural Sciences* **38 (30)** 17126 -17127
- [2] Wang Z J 2002 Study on energy-saving residential buildings in hot summer and cold winter area [J] *HVAC* **32 (3)** 24 -26
- [3] China Academy of Building Research, Chongqing University. JG J134 - 2001 hot summer and cold winter residential building energy efficiency design standards [S] Beijing: China Construction Industry Press 2001
- [4] Chen Z G 2015 hot summer and cold winter green building passive energy-saving discussion, 10.16661 / j.cnki.1672-3791.29.091
- [5] Rui W W, Ying X, Jiangsu Chuangyuan Architectural Design Co., Ltd., 10.3969 / j.issn.1673-7237.2010.02.021
- [6] Qu W Y, Ge C Y , Hot summer and cold winter villages and towns residential building energy efficiency