Industrial Engineering and Innovation Management (2023)
Clausius Scientific Press, Canada

DOI: 10.23977/ieim.2023.061017
ISSN 2522-6924 Vol. 6 Num. 10

Study on the optimal placement Angle of solar panels in rural buildings

Deqing Bu, Zhiyuan Liu

North China University of Technology, Beijing, China

Keywords: Solar technology, building energy consumption, simulation experiment, genetic algorithm

Abstract: Based on the background of rural construction and green buildings in China, this paper explores the basic situation of rural housing obtaining solar energy to meet building energy consumption. This article through to the network literature investigation arrangement, combs solar energy technology to improve the rural building energy consumption basic condition. In this paper, the simulation experiment is carried out by green building software to simulate the rural building model, in which the genetic algorithm is used to calculate the optimal placement angle of solar panels. It provides data reference for the green construction of rural buildings. It provides data reference for green construction of rural buildings.

1. Introduction

1.1 Research background:

With the "double carbon" goal proposed, as well as the new rural construction synchronization. It is an important task to vigorously promote green energy-saving design of rural buildings. In the green energy-saving construction of rural buildings, the large energy consumption caused by indoor heating and cooling is an important problem to be solved[1]. The increasing energy consumption of rural residential buildings will bring heavy pressure to the sustainable development of China's economy and society. For China, which is relatively short of resources, it is necessary to formulate feasible energy consumption strategies for rural residential buildings. As renewable energy, solar energy plays an important role in accelerating the overall building energy conservation in China, and is also an important part of the implementation of sustainable development strategy[2].

1.2 Solar system

Solar energy is the most abundant renewable energy in the world, with the advantages of universal existence, sustainable use, safety and environmental protection. Among various renewable energy sources, based on building application scenarios, the integration of photovoltaic and building has unique development advantages[3]. In recent years, with the development of the photovoltaic building industry and the maturity of technology, good products and designs can make full use of the resources of the facade of the building, reflect the integration with architectural aesthetics and the building environment, provide distributed energy for the building, but also can be insulated, thereby reducing indoor cold and heat loads, and achieving double benefits of energy saving and production capacity[4].

2. Research methodology

Green building simulation software is used to collect data on solar energy acquisition. The building simulation software used here is Ladybug and Honeybee. After collecting data, genetic algorithm is used to simulate and optimize the building to calculate the solar panel placement angle for maximum solar energy collection. On this basis, the total solar energy collected is further calculated and converted into corresponding electric energy, so as to establish the quantitative relationship between solar energy acquisition and building energy consumption in rural buildings.

2.1 Ladybug

Ladybug is a green building simulation software based on data modeling, which can be used to calculate solar sunshine duration, illumination and other related building energy consumption data.

2.2 Genetic Algorithm

The algorithm was first proposed by John Holland from the United States in the 1970s, and was designed based on the evolutionary laws of organisms in nature. It is a computational model that simulates the natural selection and genetic mechanisms of Darwin's biological evolution theory, and is a method of searching for optimal solutions by simulating the natural evolution process. This algorithm uses mathematical methods and computer simulation operations to transform the problem-solving process into a process similar to the crossover and mutation of chromosome genes in biological evolution. When solving complex combinatorial optimization problems, compared to some conventional optimization algorithms, they can usually achieve better optimization results quickly (Figure 1: Illustration of genetic algorithm).

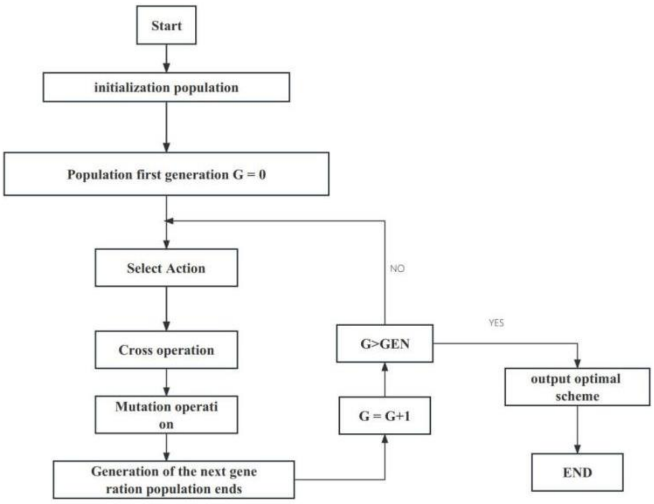

Figure 1: Illustration of genetic algorithm

3. Simulation of the analysis process

3.1 Selection of simulation site and time period

The selected location for this article is in the southwest of Shandong, a high-latitude area. The most prominent problem of rural buildings in the high-latitude area is the high energy consumption for heating in winter, and there is a common problem of low indoor temperature. The economic burden is heavy and pollution is severe, and the energy consumption of rural residential buildings is constantly increasing, which will bring heavy pressure to the sustainable development of China's economy and society.

According to the results of data simulation, it can be known that the annual climate can be divided into obvious heating season and cooling season. After obtaining the results of the preliminary data simulation, the author selects the time period in Shandong province that is lower than the comfortable temperature, and uses this time period as an example to calculate the total amount of solar energy collected by the building and the overall energy consumption of the building in this time period. According to the literature research and analysis summary, the time period selected for this experiment is October-March. The selected time period is from October to March.(Figure 2: Annual temperature)

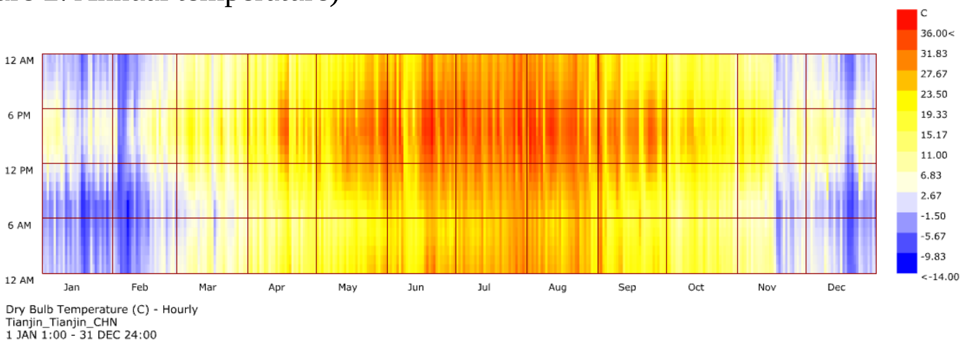

Figure 2: Annual temperature

3.2 Generic Architectural Morphological Characteristics

According to data collection and organization, rural buildings in the southwestern region of Shandong are naturally simple, generally consisting of 3-5 main rooms in the north, with many having six or seven rooms. There are also wing rooms in the east and west, and some have southern rooms. The general structure is relatively simple, with two types of roofs: flat or sloping. The flat form is rectangular or approximately rectangular. The number of layers is mainly one, with fewer second or third layers. Houses built in the early years generally had smaller bays of 3m to 3.3m and depths of 4.5m to 4.8m. In recent years, the width and depth of houses constructed have increased, with a general width of 3.6m~4.5m and a depth of 5m~8m.

There are four forms of layout for rural architectural courtyards in the southwestern region of Shandong: courtyard style, courtyard style, two sided wall style, and three sided wall style. The majority of them are enclosed on both sides with a wing room[5].(Figure 3: Building layout)

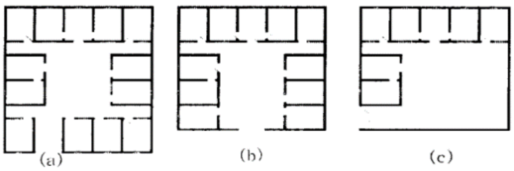

Figure 3: Building layout

The proportion of walls on both sides is the largest, so this is the basic unit of the building. A solar trajectory model was constructed in the simulation experiment and used to simulate the sunlight trajectory[6].(Figure 4: Basic prototype)

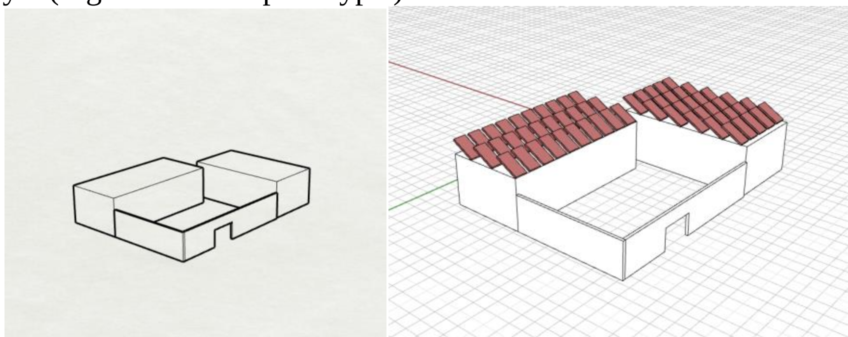

Figure 4: Basic prototype of a simulated building

3.3 Building a simulation model

Based on the basic unit of rural architecture, the model of relative position between architecture and sun is established. The time period of the experiment was from October to March, which is our significant heating energy consumption time period. (Figure5: Simulation model)

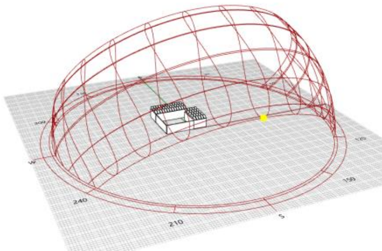

Figure 5: Simulation model

3.4 Solar radiation simulation

The model is simulated by illumination, and the illumination of solar panel in corresponding time is calculated. In the set time period, the solar panels installed in the roof space collected solar total illumination of 58324 kilowatts. 495KWH illumination per square metre. (Figure 6: Solar version of total illuminance)

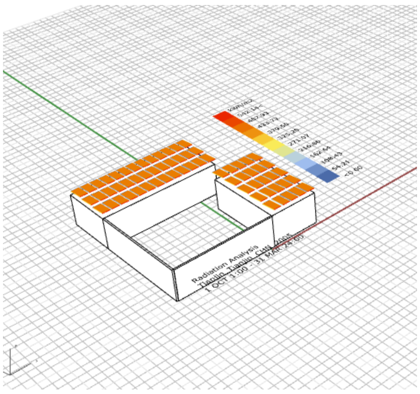

Figure 6: Solar version of total illuminance

3.5 Genetic algorithms for optimisation

3.5.1 Process of finding an optimal solution

After establishing the simulation model, genetic algorithm is used to optimize the simulation process. Firstly, the number and arrangement of solar panels in the model were established. This is based on the basic prototype of the building and the arrangement of solar panels on the roof. This method can first obtain the maximum sunshine duration, while also addressing the impact of solar panels on building aesthetics.

On the basis of the establishment of solar panel layout, the solar altitude angle is not a constant value during the period from October to March, but a value that changes over time. So the placement angle of the solar panel will definitely affect the total amount of solar energy collected by the solar panel. In order to achieve the optimal angle so that the solar panel can collect the most solar energy within a certain period of time, a genetic algorithm is used to calculate the target.

The experiment takes the rotation angle of solar panels as the independent variable, and controls this independent variable with three parameters: X,Y and Z respectively. These three parameters correspond to rotation around X axis (Figure 7: Rotation diagram around the X-axis), rotation around Y axis (Figure8: Rotation around the y-axis), and rotation around Z axis respectively. The combination of these three rotation variables can cover any rotation angle of the solar panel and any rotation angle of the solar panel.

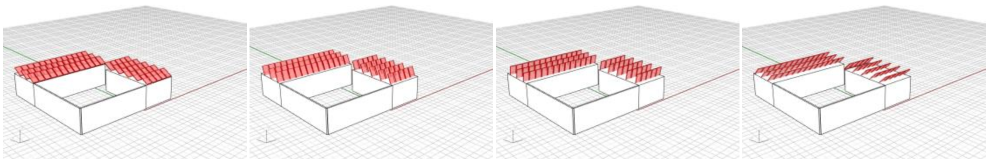

Figure 7: Rotation diagram around the X-axis

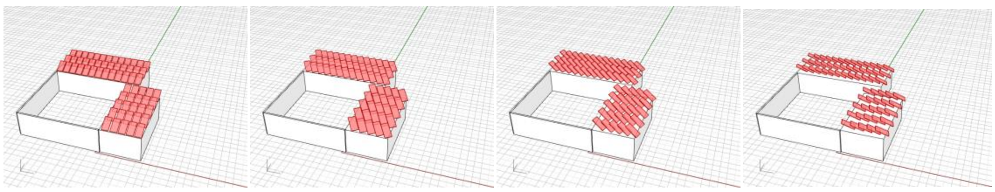

Figure 8: Rotation around the y-axis

The optimization process is based on a mathematical model, and genetic algorithm derivation is performed on the model within a certain period of time. This simulation is a single objective optimization, and the results of the algorithm will approach the optimal answer infinitely over time, which is the optimal angle of the solar panel house.

3.5.2 Genetic Algorithm Iteration Results

Due to the high computer requirements for calculating such building simulations, each simulation operation takes a lot of time. Therefore, this simulation did not reach the end of the simulation, but after the simulation reached a relatively high level, the simulation was interrupted. And select a few representative stages to show. These simulation results were collated to yield solar radiation of 400-630 kW per square meter of solar panels.

4. Conclusion

4.1 Optimal angle of placement of solar panels

According to the iteration and optimization of genetic algorithm, the final calculation results show that, taking the midpoint of solar panel as the center, the spatial angle is: rotate 50 degrees around X axis (east-west direction), rotate 5 degrees around y axis (north-south direction), rotate 30 degrees around Z axis (vertical ground direction).

4.2 Numerical value of solar energy conversion corresponding to the optimal placement angle

The current optimal solution for simulation is 625 kilowatt hours of solar radiation energy per square meter. During the period from October to March, a total of 77246 kilowatts of solar radiation energy were collected.

This simulation was established in many ideal environments, so the results obtained are only preliminary simulation results. On this basis, further simulation derivation can be conducted. His simulation is based on many ideal environments, and the computer arithmetic problem greatly simplifies the arithmetic time and logic, so the results obtained can only be a preliminary simulation, and is not really the "optimal solution".

The demonstration construction of photovoltaic buildings has been carried out since 2008, with the focus on standards, technology, and research and development of photovoltaic products applied to ground power stations. In terms of product conversion efficiency, Longji Green Energy Technology Co., Ltd.'s battery laboratory efficiency reaches 26.3%, which is currently the highest conversion efficiency in domestic laboratories. On the market, the conversion efficiency of solar panels is generally around 20%. So the total amount of solar radiation converted into electricity is 15450 kilowatt hours. Rural buildings, with an area of 120 square meters accounting for the majority, produce 128 kilowatt hours of electricity per square meter.

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