Research on building energy efficiency based on energyplus software

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Abstract. Energyplus is an important software in the field of building energy efficiency, which can accurately simulate building energy consumption. By comparing simulated situation of building energy consumption with actual usage of energy, the energy consumption can be shown in some buildings so as to optimize the building energy efficiency, especially for promoting the thermal performance of buildings. This paper utilizes the building energy simulated software—EnergyPlus to simulate the energy consumption of the dormitory of Southeast University so as to verify the key factors of building energy consumption.

1. Introduction

At present, scholars from all over the world have studied the energy consumption simulation of buildings. Several representative office buildings have been studied by energyplus in Europe. Through the simulation of several schemes, three climate zones in Europe are selected. The results show that lighting is a potential option for energy saving, and different lighting systems have different energy-saving effects. At the same time, the proportion of the exterior walls and windows of the building, are vital for energy conservation of the buildings[1]. The energy-saving effect of buildings has great significance for energy efficiency. In this paper, the EnergyPlus simulation tool is used to benchmark the energy of 400 buildings. The verification results of the building examples show that the engineering model of the production benchmark has a great impact on the performance of the building[2]. Through the simulation of the model of the rural house, the performance parameters of the enclosure are set to apply EnergyPlus to simulate the energy efficiency under different conditions, which provides technical support and theoretical guidance for the energy-saving renovation of the building[3]. Passive buildings are currently the preferred type of design that can effectively increase energy efficiency. Through the simulation of representative apartments in Shanghai, the main steps include: establishing models; sensitivity analysis and multi-objective optimization. The multi-objective optimization results elucidate that residential buildings have great potential in terms of comfort and energy saving in Shanghai[4]. Vertical Greenery Systems (VGS) is a new type of façade cladding fixture that effectively connects cities and nature. The focus of this paper is on the relationship between VGS and building energy efficiency. The verified results illustrate that the integrated VGS model can satisfactorily predict its effect and it has an influence on the indoor air temperature. Simulations demonstrate that VGS is reduced in the hot summer and the surface temperature of the building's exterior wall is reduced by 3%. In winter, VGS leads to an increase in heating needs for buildings and In the summer, VGS can reduce energy consumption[5]. In addition, there are many scholars who have conducted relevant research[6-18].
A qualified architectural design need to combine the space, form and structure of the building but at the same time, the structural materials and internal equipment and systems are used to maintain the thermal comfort of the building. In order to predict the consumption of building energy consumption and improve building energy efficiency, some results have been executed by this paper. This paper utilizes the building energy simulated software- EnergyPlus to simulate the energy consumption of the dormitory of Southeast University. Meanwhile, combined with the field and Internet data research, some unfavorable factors need to be found so as to provide reference for enhancing building energy efficiency further.

2. Meteorological conditions of building

The dormitory of southeast university is in a subtropical monsoon climate, including abundant rainfall with annual precipitation of 1200 mm, four distinct seasons, annual average temperature of 15.4 °C and annual extreme temperature of 39.7 °C. There are hot summer and cold winter, so some devices need to be installed to meet the cooling effect in summer and heating effects in winter for all students.

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3.1. Basic information of building

See the specific information of energyplus Web page[19]. The simulated object is in the campus of southeast university, which was built in 2006. The building has six layers. The total height of the building is 19.185 meters and the construction area is 3939 square meters. The outer surface area of the building is 3,545.548 square meters. The building is divided into three units, and the rooms of north and south are connected by corridors. There are 17 two-person rooms, one accommodation room on the south side of the building, and three network management rooms. The entire dormitory can accommodate the living of 229 students. An air conditioner and a water heater are provided in each room. Structural system is brick-concrete structure. Some students data can be found in table 1.

| Number of rooms | Number of rooms | Number of people | total |
|-----------------|-----------------|-----------------|-------|
| (South side)    | (North side)    |                 |       |
| First floor     | 17              | 3               | 2     | 37   |
| Second to fifth | 18              | 6               | 2     | 210  |

Table 1. Southeast University Standard Dormitory Student Statistics

Building envelope structure: hollow bricks are used for the exterior walls of the building. The interior wall is mainly made of aerated concrete blocks. The roof is made of 20 thick extruded insulation boards. The window is ordinary aluminum alloy frame glass. Table 2 shows the window area details.

|          | South (㎡) | North (㎡) | East (㎡) | West (㎡) | Sum (㎡) |
|----------|------------|------------|-----------|-----------|----------|
| First floor | 46.56      | 33.69      | 10.29     | 10.29     | 100.83   |
| Second to fifth | 55.9       | 43.35      | 16.23     | 16.23     | 131.71   |
| Sixth floor  | 49.8       | 43.35      | 10.29     | 10.29     | 113.73   |
| Stairs      | 84.87      | 16.66      | 16.66     | 16.66     | 118.19   |
| Total       | 152.26     | 205.26     | 53.47     | 53.47     | 464.46   |

Building electrical lighting setup: a ceiling light for each double room in the building. The room is equipped with a double tube fluorescent lamp, a hanging air conditioner and six sockets. There are 18 single-tube fluorescent lamps on each floor of the corridor, and a ceiling lamp is placed near the
stairway. Each bathroom is equipped with a waterproof light, and each living room is equipped with a double-tube fluorescent lamp and five sockets. The specific setting information is shown in Table 3.

| Electrical equipment type | Number | Number of rooms | Single power |
|--------------------------|--------|-----------------|--------------|
| Thermal zone 1           | Lamp   | 1               | 108          | 22W          |
|                          | air conditioning | 1               | 108          | 2430         |
|                          | Water heater | 1               | 108          | ~            |
| Thermal zone 2           | Lamp   | 1               | 108          | 2*40w        |
|                          | Electrical plug | 1               | 648          | ~            |
| Thermal zone 3           | Lamp   | 1               | 108          | 40w          |
|                          | Lamp   | 1               | 18           | 22W          |
| Thermal zone 4           | Lamp   | 1               | 36           | 2*40w        |
|                          | Lamp   | 1               | 36           | 60w          |
| Thermal zone 5           | Lamp   | 1               | 108          | ~            |
|                          | Electrical plug | 1               | 180          | ~            |

3.2. Building model setting
The design of the dormitory is generally neat, with only a slight difference between the bottom and top floor balconies. In order to ensure the stability of the computer operation in this modeling process, the building shape is simplified and integrated, and the effect is shown in the figure 1.

Figure 1. Dormitory building in Southeast University

The area of the window of the building is counted through the architectural drawings in all directions. It is 152.26 square meters in the south, 205.26 square meters in the north, 53.47 square meters in the east and 53.47 square meters in the west. The error between the model window opening area and the actual window opening area is within 1%.

The building is divided into five thermal divisions according to the indoor thermal requirements of the environment. The south-facing balcony and the door of the room are often closed and there is no air-conditioning device in the space, which is set as Thermal Zone 1 (The Thermal Zone 1). Each of the south-facing dormitory rooms uses an air conditioner, which is set to Thermal Zone 2 (Thermal Zone 2). The corridor channel is divided into two areas, north and south, and is set to Thermal Zone 3 (Thermal Zone 3). The room with the same type of air conditioner on the north side is set to Thermal Zone 4 (Thermal Zone 4). There are no air conditioning in the living space and the traffic area and are set to Thermal Zone 5 (The Thermal Zone 5). According to this method, 16 thermal zones are established from the bottom layer to the sixth floor.

3.3. Calculation parameter setting of EnergyPlus
The simulation control is set to automatically calculate the cooling and heating load of the building. Set the software calculation operation step to 6 of one hour. Set the heat balance algorithm. The convection heat transfer algorithm is a variable natural convection based on temperature difference for setting the inner surface of the building. The convective heat transfer algorithm on the outer surface of the building is a rough surface correlation algorithm. The operating period is from January 1 to December 31.

Outdoor environmental parameters are geographical location information of Nanjing area.

Some enclosure parameters: materials: hollow brick, glass, surface tiling and surface coating layer with their thermal related parameters; structure: the outer wall is constructed as - tiling - plastering - hollow brick – plastering and the glass thickness is clear10mm. The thermal zones of the building information can be displayed in table 4.

| zonelist | Thermal zone | Mean         |
|----------|--------------|--------------|
| sunspace | Thermal Zone1; Thermal Zone6; Thermal Zone11 | South balcony space |
| bedroom1 | Thermal Zone2; Thermal Zone7; Thermal Zone12 | South bedroom room |
| corridor | Thermal Zone3; Thermal Zone8; Thermal Zone13 | corridor |
| breakroom | Thermal Zone4; Thermal Zone9; Thermal Zone14 | North living space |
| bedroom2 | Thermal Zone5; Thermal Zone10; Thermal Zone15 | North bedroom room |
| 1st floor | Thermal Zone1——ThermalZone5 | 1st floor of dormitory |
| 2-5 floor | Thermal Zone6——ThermalZone10 | 2-5 floors of dormitory |
| 6th floor | Thermal Zone11——ThermalZone15 | Top floor |
| Abat-vent | thermal Zone16 | Sloping roof |
| All | Thermal Zone1——Thermal zone16 | All thermal zone |

Operating schedule: lighting time, electrical equipment usage time, air conditioning usage time, water heater usage time and rest time. The students get up between 6 and 8 in the morning and return to the bedroom after 9:00 in the evening. During this period, the sockets are used for computer equipment. The lighting use time of the lamps is from 6 am to 8 am, and 9 to 11 pm. The socket is used from 9:00 to 10:00 pm. Air conditioning is available from 9pm to 5am. The water heater is heated from 6pm to 10pm. The law of personnel activities is basically consistent with the lighting of the lamps and the radiation heat dissipation coefficient is set to 0.3.

4. Conclusion
By way of the simulation of 12 months of electricity consumption in the building (figure 2 represents the Electricity consumption details of targeted buildings), it is found that the energy consumption is higher from December to February and from July to August. The reason is that the energy consumption of air conditioning heating is the largest in winter, followed by the cooling in July and August in summer. The findings are basically consistent with the assumptions.

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[19] DOE, EnergyPlus Energy Simulation Software, Internet.

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