The determination of simultaneous use coefficient for load prediction of the tourism resorts

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Abstract: Load prediction of regional buildings is the basis of equipment capacity allocation of regional energy system. However, the equipment capacity of the energy system is usually too large and unnecessary energy consumption is wasted. It is very important to choose an effective load prediction method. In this paper, scenario analysis and software simulation methods are combined to simulate the cooling load and heating load of the tourism resorts, then the load and the simultaneous use coefficients of the tourist resorts under different building ratios are obtained. The proposed method is simple and effective, and it can provide reference values of simultaneous use coefficients for similar projects in the future.

1. Introduction
Tourist resort refers to a group of buildings for leisure and entertainment, generally located in a tourist area, far from the city. Its energy supply system mostly adopts regional energy system, which can effectively utilize renewable energy [1], and improve the unit operation efficiency [2]. However, the allocation of the equipment capacity is usually excessive, which results in unnecessary energy waste. The reason is the design load of the energy system is too large, thus the load prediction method is important and worthy studying. In this paper, the cooling and heating load of different buildings under different building ratios in a tourist resort is simulated, and the results are compared with those of the area index method. Moreover, the simultaneous use coefficient of the buildings are obtained, which could provide a reference for energy planning of a tourist resort.

2. Method
At present, area index method is mostly used for calculating the load of a single building and district buildings. The load of a single building can be calculated by equation (1).

\[ Q' = A \times q' \]  

where \( Q' \) is the load calculated by the area index method; \( q' \) is the area index; \( A \) is the building area.

In practical projects, to calculate the load of the district buildings, following processes are usually conducted: (1) the load of each building is calculated according to the heating or cooling index by Eq. (1); (2) the load of the single building is simply superimposed; (3) the load of the district buildings is obtained by multiplication of the sum of the single building load and the simultaneous use coefficient. However, the selection of the simultaneous usage coefficient is mostly based on experiences, lacking of accuracy.
Some methods have been used to predict load. The simulation method, which uses energy consumption software to predict the load of buildings, has high accuracy and can reflect the dynamic change characteristics of the load. Heiple et al. [3] used e-quest to simulate building energy consumption. Scenario analysis is a method which set different scenarios for various factors affecting the load of buildings, then calculate the load under different scenarios [4]. Garrido-Soriano et al. [5] adopted the scenario analysis method to find out the energy saving potential, economic performance, and greenhouse gas emissions. Based on these methods, this paper chooses the method which combines simulation and scenario analysis to predict the load of tourist resorts.

The specific steps are as follows:

1. Determine the main types of the district buildings, then set up different scenarios, and establish corresponding models under different scenarios;

2. Simulate the load of typical buildings under different scenarios, and then extend it to the whole district buildings.

In addition, the simultaneous use coefficient is introduced and calculated for directing the energy planning. At the present, the simultaneous use coefficient is mostly determined based on experience or specifications [6], and it often results in inaccurate load prediction results. In this paper, the load under different scenarios is simulated, and the simulation results are compared with those of the area index method. Finally, the simultaneous use coefficient of the district buildings is obtained. The simultaneous usage coefficient \( k \) can be calculated according to equation (2):

\[
k = \frac{Q}{Q_i}
\]

where \( k \) is the simultaneous use coefficient, \( Q \) is the load simulated by the software.

3. Case study

3.1 Project overview
A tourist resort, located in Changsha, covering an area of 80000 m², with a total area of 100000 m² is selected as the study object.

3.2 Scenarios
Establishing typical building models [7] can greatly reduce the calculation complexity and improve its accuracy. Therefore, the district buildings are classified into residential buildings, office buildings and entertainment buildings in this paper.

The tourism resort is dominated by residential buildings, thus the proportion of residential buildings is 0.5-0.8. The proportion of office buildings is 0.1-0.4. And the proportion of entertainment buildings is 0.1-0.4. Ten scenarios are established in Table 1.

| Scenario | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|----------|----|----|----|----|----|----|----|----|----|----|
| Residential | 0.5| 0.5| 0.5| 0.5| 0.6| 0.6| 0.6| 0.7| 0.7| 0.8|
| Office    | 0.4| 0.2| 0.3| 0.1| 0.2| 0.3| 0.1| 0.2| 0.1|    |
| Entertainment | 0.1| 0.3| 0.2| 0.4| 0.3| 0.2| 0.1| 0.2| 0.1|    |

Then DEST is used to simulate the load of each building under above 10 scenarios. To simplify the simulation, the parameters of the building envelopes of the different buildings are set as the same and shown in Table 2.

| Envelope     | Material               |
|--------------|------------------------|
| Roof         | Cement perlite roof    |
| Exterior wall | Concrete wall          |
| Interior wall | Brick wall             |
| External windows | Standard outdoor window |
3.3 Results

The load simulation results of the district buildings are shown in Table 3. 

Table 3. Load simulation results.

| Scenario | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Heating load (kW) | 9970 | 8709 | 8137 | 8213 | 11945 | 11999 | 12412 | 12999 | 12619 | 13508 |
| Cooling load (kW) | 28217 | 25985 | 27477 | 24340 | 42708 | 43254 | 43755 | 47004 | 46559 | 50621 |

According to Table 3, when the ratio of the district buildings is 0.5, 0.2, 0.2 (scenario 3), the heating load of the tourist resort is the minimum; when the ratio is 0.5, 0.1, 0.4 (scenario 4), the cooling load is the minimum.

The load of the area index method is also calculated. The area indexes of heating load are as follows: 50W/m² for the residential building, 60W/m² for the office building and 90W/m² for the entertainment building. While the area indexes of the cooling load are: 130W/m² for the residential building, 110W/m² for the office building and 130W/m² for the entertainment building [8]. The calculation results of the area index method are shown in Table 4.

Table 4. Load calculation results.

| Scenario | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Heating load (kW) | 18480 | 17040 | 17760 | 16320 | 18000 | 18720 | 19440 | 19680 | 20400 | 21360 |
| Cooling load (kW) | 43360 | 41280 | 42320 | 40240 | 44880 | 45920 | 46960 | 49520 | 50560 | 54160 |

Table 5. Difference between two load results.

| Scenario | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Heating load (kW) | 8510 | 8331 | 9623 | 8107 | 6055 | 6721 | 7028 | 6681 | 7781 | 7852 |
| Cooling load (kW) | 15143 | 15295 | 14843 | 15900 | 2172 | 2666 | 3205 | 2516 | 4001 | 3539 |

To compare the load results of the simulation method and the area index method, the differences between them are calculated and shown in Table 5. It can be found that the load results obtained by area index method are much larger than those obtained by simulation. The maximum difference of heating load is 8510 kW (scenario 1) and the minimum is 6055 kW (scenario 5); the maximum difference of cooling load is 15900 kW (scenario 4) and the minimum is 2172 kW (scenario 5). In addition, the results calculated by area index method show a little change in different scenarios, and the simulation results especially the cooling load show obviously change, varying from 24340 kW to 50621 kW. To sum up, the results of the area index method are larger than the simulation results, resulting in a great waste of energy.

To obtain a more accurate simultaneous use coefficient, and provides reference values for the energy planning in future projects, the simultaneous use coefficients are calculated by equation (2). The results are shown in Table 6.

Table 6. The simultaneous use coefficient.

| Scenario | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| K (cooling) | 0.54 | 0.51 | 0.46 | 0.50 | 0.66 | 0.64 | 0.64 | 0.66 | 0.62 | 0.63 |
| K (heating) | 0.65 | 0.63 | 0.65 | 0.60 | 0.95 | 0.94 | 0.93 | 0.95 | 0.92 | 0.93 |

According to Table 6, the simultaneous use coefficient of the tourist resort in summer are relatively small, varies from 0.46 to 0.66; while in winter, the coefficients are generally higher than those in summer, of which the highest is 0.95, and the lowest is 0.63. When calculating the load of a tourist
resort, the appropriate simultaneous use coefficient can be selected, and it can avoid the irregularity and improve the accuracy of the load prediction. Furthermore, it can avoid unnecessary energy consumption.

4. Conclusion
In this paper, the load of a tourist resort is firstly predicted by using the method combining software simulation and scenario analysis. Then the simulation results are compared with the results of the area index method. The load differences are calculated and the simultaneous use coefficients under different building ratios are obtained. The results can provide reference values of the simultaneous use coefficients for the same resorts. And it can improve the accuracy and rationality of the load prediction, meanwhile, it can avoid the excessive capacity of equipment. Moreover, it is beneficial to reduce unnecessary energy consumption.

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