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Study on Electricity Utilization Rules of Light Sockets in Governmental Office Buildings in Chongqing

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Abstract

This paper is based on the energy consumption monitoring platform of the office buildings and large-sized public buildings of the state organs in Chongqing. The writer selected one office building with complete set of data and normal operation as the case building to analyze electricity for lighting sockets in the building and find out the rule and features of electricity utilization. In addition, we selected 5 buildings to demonstrate the rule and compared the results with the standard plants.

Keywords*: energy consumption monitoring platform, light sockets, electricity features*

1. Introduction

According to statistics, the data in 2011 shows that the total energy consumption of buildings in our country was 687 million tce, accounting for 19.74% of the nationwide total energy consumption, of which, energy consumption of public buildings was 171 million tec, accounting for 24.89% of the total energy consumption of buildings [1, 2]. Generally, electricity for lighting sockets and one for air conditioners in the public buildings were respectively 46% and 32% in all the buildings. However, the ratios of electricity for lighting and air conditioners in the business buildings were 37% and 42% respectively. The ones in the hotel buildings were 48% and 28% respectively, while the ones in the office buildings were 44% and 36% [3, 4], which shows that except for electricity for air conditioners in some of buildings standing on the first place, electricity for lighting sockets in most of the buildings has stood on the first place in energy consumption of buildings even has exceeded electricity for air conditioners in some buildings [5]. Therefore, considering that energy-saving reconstruction of electricity for light sockets has become the key point of current energy-saving reconstruction, the electricity utilization feature corresponding to it is the key point to determine and analyze the reasonability of electricity utilization [6]. Therefore, when studying on the electricity utilization rule of lighting sockets, it is very important to analyze and calculate electricity utilization ratio of the buildings at each period of time per day [7-9].

The energy consumption monitoring platform of office buildings and large-sized public buildings [10] of the state organs in Chongqing is used to monitor electricity for four kinds such as air conditioners, lighting sockets, power and special purpose in the building [11] and mainly collect the real time data of classified energy consumption and subentry energy consumption of the building, including secondary sub-item data under the subentry data and each subentry data [12], for example electricity for lighting sockets, garage, bright lighting and switch board room at each floor. In order to analyze the change rule of electricity for lighting sockets during operation of the buildings, the writer selected the data during one week of operation of the building in this paper, including four sub-items such as lighting sockets, air conditioners, power and special purpose. At the same time, the writer analyzed the rule varied with consumption time of electricity for lighting sockets in the actual operation of the buildings in combination with the building equipment information and its operation management features investigated and collected.

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2. Detailed Introduction to the Case BuildING

2.1. Electric Equipment Information of Lighting Sockets in the Building

The case building refers to one typical governmental office building with building area 11508 m2 and 6 floors, including floor 1-4 as office area of a governmental unit and floor 5-6 for hotel building. The studied object of this paper is the office areas at floor 1-4 of the building, provided with Chongqing municipal energy consumption monitoring system, and air conditioners with cold air and heat pump. The operation time of the building is office hour 09:00-17:00 each day, total 5 days one week, with two-day off.

The electric equipments of lighting sockets in the building mainly include lighting fixtures (fluorescent lamp, filament lamp and halide lamp etc.), office equipments (computer, printer and duplicator etc.) and domestic electricity (water dispenser and TV set etc.). According to the functional distribution of the building floor, through investigation we know that average number of offices put into operation during period of work at floor 2-4 is about 20 rooms per floor.

2.2. Detailed Information of Energy Consumption Monitored at the Lighting Sockets in the Case Building

Energy consumption of lighting sockets in the case building mainly includes energy consumption of lighting fixtures, sockets of office equipments and bright lighting in the building. In order to analyze the electricity utilization rule, in this paper, the writer collected energy consumption data of 8 secondary subentry items, including electricity for lighting sockets at floor 1-4, garage light fixtures, garage, ceiling light fixtures and switch board room.

3. Analysis of the Electricity Utilization Rule of Light Sockets in the Building

Through investigation of the buildings, the writer found out that the building has not other energy consumption except for normal office hour, without overtime in the investigated period of time except for office hour 09:00 - 17:00.

3.1. General Rule of Electricity for Lighting Sockets in the Building

The writer analyzed it by selecting the real time energy consumption of the case building from Jan 20 – Jan 26, 2013, i.e. 7 days of one week, of which, Jan 20, 2013 is Sunday, Jan 21 - Jan 25 is Monday to Friday, and Jan 26 is Saturday. The energy consumption data of one week is as shown in the following figure:

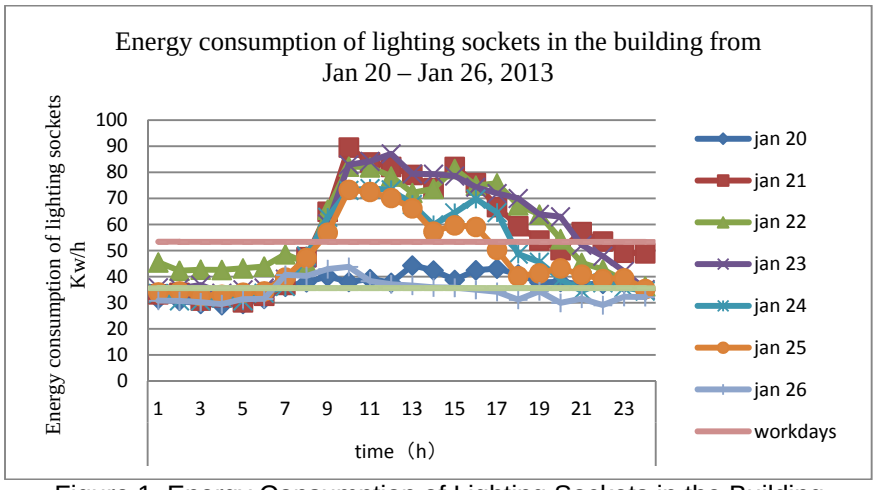

Figure 1. Energy Consumption of Lighting Sockets in the Building

As shown in the Figure 1, the energy consumption of lighting sockets on working days is 53.35kwh/h, while the one on weekend is 35.65kwh/h. The curve change on five working days is uniform. Compared to the curve on non-working day, the one on working day has a

large difference and the one on non-working day is rather gentle, which is maintained on a balanced value on the whole day.

The curve trend in the figure shows that the energy consumption of lighting sockets in the building on the working day is regular and is increased with the time from 01:00 to 08:00, almost keeping constant, and the curve is kept gentle from Jan 21 to Jan 25, 2013. The energy consumption is increased with the time from 08:00 to 10:00 but the energy consumption fluctuation is very little and the curve is rather gentle with the time change from 10:00 to 12:00, and is the maximum value of energy consumption data on the whole day. The energy consumption is decreased slightly with increase of the time from 12:00 but the one would start to rise again with increase of the time from 14:00 and would continuously rise up with increase of the time from 14:00 to 16:00, and then would continuously drop with increase of the time from 16:00 to 17:00. The drop trend would become gentle from 17:00 to 20:00 and keep to 20:00 until end of the day. The following is the artificial division of one day, totally seven stages such as 08:00-10:00, 10:00-12:00, 12:00-14:00, 14:00-16:00, 16:00-17:00, 17:00-20:00 and 20:00-08:00. The writer uses the data on Jan 24 for detailed analysis as follows:

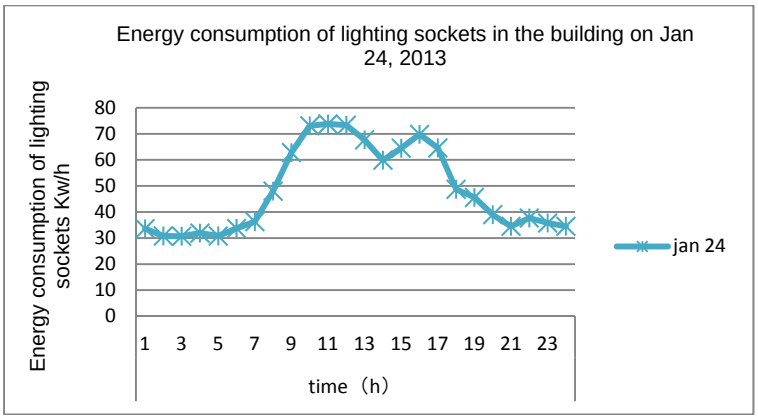

Figure 2. Energy Consumption of Lighting Sockets in the Building on Jan 24, 2013

Assuming that the average energy consumption 71.98kw/h is full load 1 from 10:00 to 12:00, the writer uses it to respectively calculate ratios of energy consumption at other periods of time. We found out that the average energy consumption value from 08:00 to 10:00 is 49.03kw/h, accounting for 0.68, the one from 12:00 to 14:00 is 63.8kw/h, accounting for 0.89, and the one from 14:00 to 16:00 is 67.15kw/h, accounting for 0.93, and the one is 56.65kw/h from 16:00 to 17:00, accounting for 0.79, and the one is 42.3kw/h from 17:00 to 20:00, accounting for 0.59 and the one from 20:00 to 08:00 is 33.77, accounting for 0.47. The energy consumption data on five days of one week is calculated and shown in the following table:

Table 1. Ratio at Each Period of Time on Working Day of the Building

	1.21		1.22		1.23		1.24		1.25		Average
08:00-10:00	49.77	0.58	53.17	0.66	48.9	0.58	49.03	0.68	47.93	0.67	0.63
10:00-12:00	85.13	1.00	80.83	1.00	84.73	1.00	71.98	1.00	72	1.00	1
12:00-14:00	76.5	0.90	72.9	0.90	79.35	0.94	63.8	0.89	61.75	0.86	0.9
14:00-16:00	79	0.93	78.1	0.97	76.45	0.90	67.15	0.93	59.4	0.83	0.91
16:00-17:00	63.05	0.74	71.6	0.89	70.95	0.84	56.65	0.79	45.25	0.63	0.78
17:00-20:00	52.05	0.61	59.1	0.73	63.45	0.75	42.3	0.59	42.25	0.59	0.65
20:00-08:00	42.19	0.50	42.05	0.52	39.85	0.47	33.77	0.47	36.19	0.50	0.49

The ratio data at each period of time is as show in the Figure below:

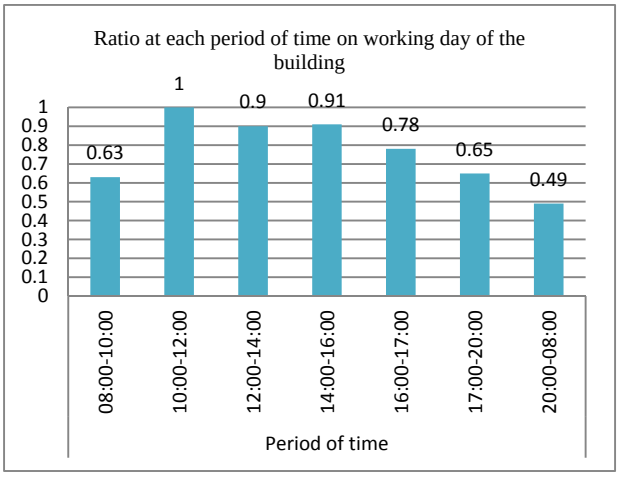

Figure 3. Ratio at Each Period of Time on Working Day of the Building

Through investigation and analysis, the above calculated results show that general office equipments and lighting fixtures in the offices of the building would continuously increase energy consumption of lighting sockets from 08:00 - 10:00, accounting for 0.63 of full load of the building and keep normal state of offices from 10:00 to 12:00, and the load is on the maximum stable state and start slight drop from 12:00 to 14:00. This period of time is the time for dinner and rest in the building. The curve obviously shows the change process in the rest time, and the ratio is 0.9. After the midday rest, the office equipments and lighting fixtures in the building would be started again so that the energy consumption would be increased from 14:00 to 16:00 and the ratio is 0.91. The curve takes on obvious drop trend from 16:00 to 17:00 because it is close to the closing time and the staffs would successively leave the building. The ratio is 0.78 during the period of time. After 17:00, the curve drop trend becomes gentle until 20:00, and the ratio is 0.65 during the period of time. The drop trend keeps gentle until the day is ended. The ratio is 0.49 during the period of time.

As for the non-working day, the curve keeps gentle on the whole day, without large fluctuation. The calculation shows that the average energy consumption is 36.91kw/h on Jan 21 and is 34.40kw/h on Jan 26. The ratio of full load on Saturday and Sunday are calculated as shown in the following table:

Table 2. The Maximum Load Ratio of Each Non-working Day in All the Working Days of the Building

Time	1.21	1.22	1.23	1.24	1.25	Average
Jan 20 (Sunday)	0.43	0.46	0.44	0.51	0.51	0.47
Jan 26 (Saturday)	0.40	0.43	0.41	0.48	0.48	0.44
Average	0.42	0.44	0.42	0.5	0.5	0.46

The results in the above table show that the average ratio value of the full load of energy consumption on non-working day in all the working days of the building is 0.46, and is close to the ratio from 20:00 to 08:00 of working day. The curve in the figure shows that the curve from 20:00 to 08:00 of the working day is almost coincided with the one of non-working day and is in line with the calculated result.

3.2. Verification of Energy Consumption Rule of Lighting Sockets in the Building

In order to verify whether the rule found out in the case building is applicable for general office building or not. The writer selected 5 buildings from the buildings monitored by Chongqing energy consumption monitoring platform. The date, area, function and life service of building are

similar to one of the case building. Through calculation, the calculated ratio results at each period of time in the five buildings are as shown in the following table:

Table 3. Ratio at Each Period of Time in Multiple Buildings

	Case building	Building A	Building B	Building C	Building D	Building E	Average value
8:00-10:00	0.63	0.57	0.68	0.58	0.62	0.56	0.61
10:00-12:00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12:00-14:00	0.90	0.77	0.87	0.88	0.86	0.78	0.84
14:00-16:00	0.91	0.87	0.84	0.88	0.82	0.76	0.85
16:00-17:00	0.78	0.66	0.66	0.71	0.65	0.70	0.69
17：00-20:00	0.65	0.24	0.34	0.27	0.35	0.35	0.37
20:00-08:00	0.49	0.19	0.34	0.29	0.26	0.26	0.31
Non-working day	0.46	0.18	0.27	0.23	0.24	0.23	0.27

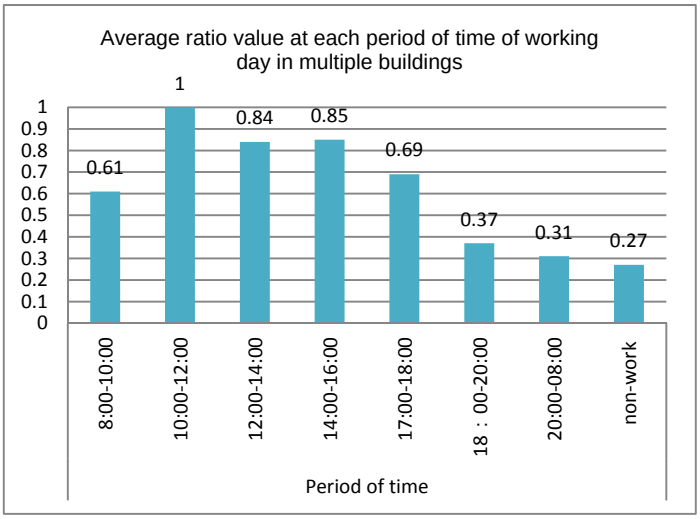

Figure 4. Average Ratio Values at Each Period of Time of Working Day in Multiple Buildings

The results in the above table show that the ratio distribution at each period of time in the five buildings is basically uniform. The ratio values of the case building from 18:00 to 20:00 and 20:00 to 07:00 are larger, which will be analyzed in detail below. The conclusion can be obtained from it that for the office buildings in Chongqing, one day can be divided into 7 periods of time according to the service time and the full load from 10:00 to 12:00 is assumed as 1, then the ratio from 07:00 to 10:00 is 0.61, the ratio from 12:00 to 14:00 is 0.84, the ratio from 14:00 to 16:00 is 0.85, the ratio from 16:00 to 18:00 is 0.69, the ratio from 18:00 to 20:00 is 0.37, the ratio from 20:00 to 07:00 is 0.31 and the ratio on non-working day is 0.27.

3.3. Comparison with the Stipulations in the Local Standards

The state standard GB-50189-2005 “Design Standard for Energy Efficiency of Public Buildings” has the following specific stipulations for lighting On/Off time when calculating load of air conditioners [13]:

DBJ50-052-2006 “Design Standard for Energy Efficiency of Public Buildings in Chongqing” provides the On/Off ratio when calculating lighting energy consumption of office building, as shown in the following table [14]:

Table 4. Lighting On/Off time %

	1	2	3	4	5	6	7	8	9	10	11	12
Working day	0	0	0	0	0	0	10	50	95	95	95	80
Festival and holiday	0	0	0	0	0	0	0	0	0	0	0	0
	13	14	15	16	17	18	19	20	21	22	23	24
Working day	80	95	95	95	95	30	30	0	0	0	0	0
Festival and holiday	0	0	0	0	0	0	0	0	0	0	0	0

Table 5. Lighting On/Off Timetable of Office Building

	On/Off %			
	7:00-8:00	8:00-18:00	18:00-21:00	22:00-7:00
Working day	50	90	50	0
Festival and holiday	0	0	0	0

Comparing the calculated results in this paper with the state and local standards, the results are show in the following figure:

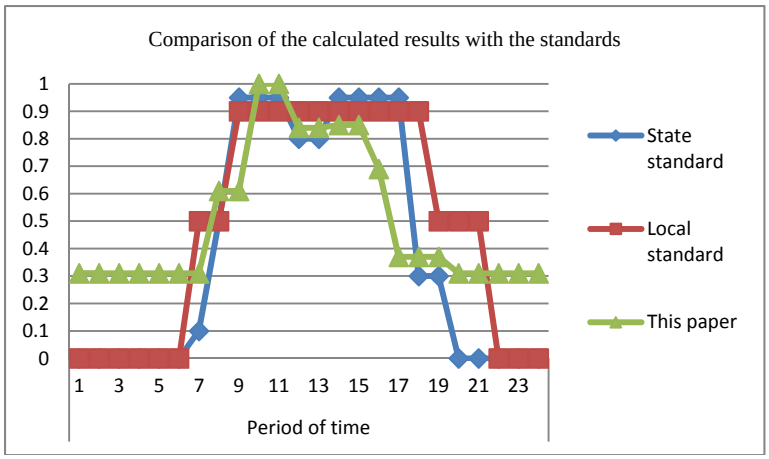

Figure 5. Comparison of the Calculated Results with the Standards

The above figure shows that the general trend of the three curves is uniform with increase of the time, which shows that the general distribution rule at each period of time of the whole day during operation of the building has uniformity. Comparing the change trend of the tree curves with the time, it shows that the results calculated in this paper are more accurate on selection of period of time or calculation of the ratio value.

The date in the figure shows that the ratios from 7:00 to 8:00, 8:00 to 18:00 and 18:00 to 21:00 of the working day are respectively 0.5, 0.9 and 0.5, and are basically similar to 0.61, 0.85 and 0.37 calculated in this paper. Comparing the results calculated in this paper with the ones in the standards, the data on non-working day has a large difference from the one during closing time. The ratio in the standard is 0 while the energy consumption ratios on non-working day and during closing time are still 0.27 and 0.31 respectively, which shows that the energy consumption of lighting sockets in the building still exists even if the building is not operated, and the ratio is assignable, which shall be analyzed as a factor that must be noticed during operation of the building [15, 16].

Compared to the local standard in Chongqing, the building is only divided into 4 periods of time, which cannot be used to fully analyze a series of complicated changes during operation of the building. However, it is divided into 7 periods of time in this paper. Compared to the period of time specified in the standard, it is more clear and detailed. The ratio at each period of time in the whole day is accurately analyzed, and the midday rest etc. during operation of the building is considered. Therefore, the result more represents the actual operation state of the building.

4. Conclusion

In this paper, through analysis of energy consumption of lighting sockets in the office buildings and large-sized public buildings of the state organs in Chongqing monitored by the energy consumption monitoring platform, we mastered the ratio distribution of energy consumption of lighting sockets in the building at each period of time within one day, as shown in the following table:

Table 6. Ratio of Energy Consumption at Each Period of Time in the Building

Period of time	Ratio
8:00-10:00	0.61
10:00-12:00	1
12:00-14:00	0.84
14:00-16:00	0.85
16:00-17:00	0.69
17：00-20:00	0.37
20:00-08:00	0.31
Non-working day	0.27

Comparing the data with the one specified in the state and Chongqing local standards, the calculated results in this paper is more detailed and accurate compared to the ones in the standards on the division of periods of time and the calculated results of ratio, which shows that the ratio 0 at the non-working period of time in the standard is not in line with the actual operation state of the building. This result can be used to guide energy-saving reconstruction of future public.

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