

# Office Building Energy Consumption based on eQUEST

Guide: Mr.Mohit Tiwari

## Abstract

The energy situation in India remains troubled, with building energy consumption continuing to dominate a large proportion of the total amount. In such case, it is important to analyze the data and issue recommendations on energy uses in public buildings. By selecting appropriate simulation software, namely eQUEST, information of actual buildings, including public utility rates and meteorological parameters, can be simplified. Some control variables was chosen to be simulated by eQUEST, such as lighting power density, indoor personnel density, summer indoor design temperature and summer air supply temperature. We summarize the impact on the power consumption of buildings based on the different variables. The respective effect of every aspect on the total power consumption is studied through the method of control variables.

Keywords: Office Building; Energy consumption simulation; eQUEST; Control variables

## 1. Introduction

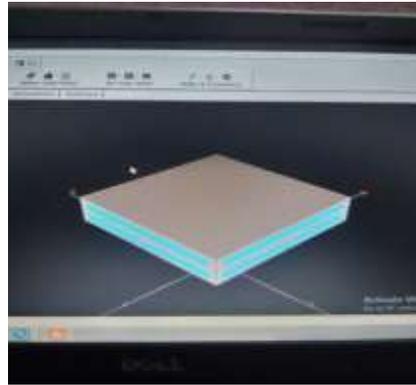
India's current building energy situation is not optimistic. Total building energy consumption accounted for the total social energy consumption is gradually stepping up. By the end of 2014, the building energy consumption in India accounted for about 1/3 of total social energy consumption. Compared to developed countries with similar climatic conditions, heating and air conditioning energy consumption per square meter in India's buildings in is approximate 3 times that of developed countries.

In recent years, many researches on building energy consumption simulation are concentrated on the office buildings, residential buildings, large space buildings and hospitals etc. [1-3]. Few researchers involved in the energy consumption simulation of office building. Office belongs to large public building in which the energy consumption is very huge. So it is worthy of doing research in this area. Due to the lack of related simulation data analysis to the public building namely office energy consumption, we established the energy consumption simulation of a office located in North India, and analyzed the different variables how to affect the building energy consumption in this paper.

## 2. Methods

Recently, a large number of research articles related to building energy consumption simulation were published by many professionals and scholars based on eQUEST software. For example, Chris Leung [4] carried on a research of building energy saving through improving indoor thermal comfort and reducing indoor temperature during sleeping. Many reliable conclusions on improving building energy efficiency were drawn by using eQUEST. Therefore, we also applied the feasible software eQUEST to acquire simulation data in this study. We selected Tianjin Polytechnic University library as the simulated building. After a reasonable simplification, the building model was created in eQUEST based on field investigation and final construction drawings. The model of university library includes two stories without basement. Its' storey height is 4.5 meters, and the building is 15.95 meters high totally. The total construction area of the library is 13050 square meters. Building structure is cast-in-situ reinforced concrete frame structure. The building shape is rectangular. The whole building is about 225 meters long, and about 58 meters wide. It mainly divided into office area, read area, copy room, multi- media room, computer room, library and other functional areas. Office area, read area and collection area are the main functional areas. Central air conditioning system is adopted for fan coil units plus fresh air

system. Cooling and heat sources are provided by the ground source heat pump system. The building model created by eQUEST.



Due to the operating characteristics of the office building, the whole year of building simulation is divided into three running time. The first stage is February for winter vacation. The second stage is the normal operation stage (January, March to June, and September to December), and the last stage (July and August). In order to run simulation smoothly, many parameters related to this building were input in eQUEST. The parameters set in the base case were acquired in field measurement. Computer room equipment load and office equipment load are set to 27 W/SqFt (291.6 W/m<sup>2</sup>) and 1.5 W/SqFt (16.2 W/m<sup>2</sup>) respectively. Lighting loads in reading area, office and book stacks areas are all set to 0.6 W/SqFt (6.5 W/m<sup>2</sup>). Lighting load in the lobby is set to 1.77 W/SqFt (19 W/m<sup>2</sup>). Lighting load in the corridor is set to 0.57 W/SqFt (6.2 W/m<sup>2</sup>). Indoor design temperature in summer and in winter is set to 24 °C and 22 °C respectively. The supply air temperature in summer and in winter is set to 13 °C and 35 °C separately.

In this study, we use the control variables method which often allows the clear identification of cause and effect because only one factor is different at a time, the effect of that single factor can be determined. Some control variables was chosen to be simulated by eQUEST, such as lighting power density, indoor personnel density, summer indoor design temperature and summer air supply temperature. There are five cases in one control variable simulation.

Variables	Case 1	Case 2	Case 3	Case 4	Case 5
Lighting Power Density	0.6 W/Sq ft (6.5W/m <sup>2</sup> )	0.93 W/Sq ft (10 W/m <sup>2</sup> )	1.39 W/Sq ft (15 W/m <sup>2</sup> )	1.85 W/Sq ft (20 W/m <sup>2</sup> )	2.3 W/Sq ft (25 W/m <sup>2</sup> )
Indoor Personnel Density	140sf/person	170sf/person	200sf/person	230sf/person	260sf/person
Summer indoor design temperature	80.6°F 27°C	78.8°F 26°C	77°F 25°C	75°F 24°C	73.4°F 23°C
Summer supply air temperature	16°C	15°C	14°C	13°C	12°C

### 3. Results

Base on the setting parameters in base case, the simulation results are shown in Fig. 2. It shows that the largest power consumption is up to 872000 KWh in June. However, the minimum power consumption is only 327300 KWh in February which is only 37.5 percentage of power consumption in June.



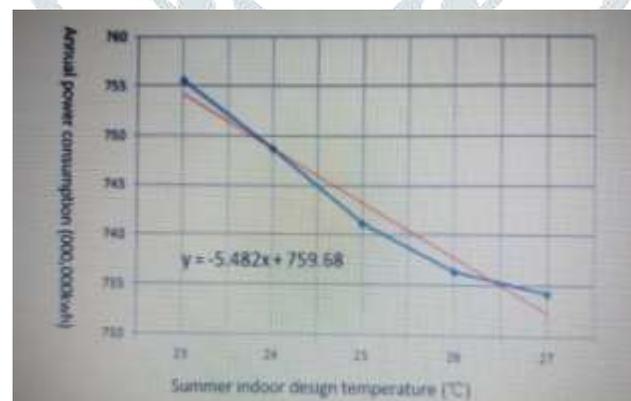
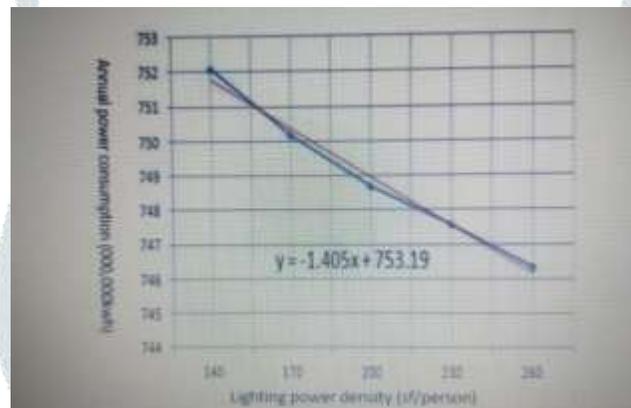
During winter vacation, the building was not open to the public, so the energy consumption in February is a minimum. In June, the building load increases with outdoor temperature, so air conditioning power consumption reaches the maximum. Calculated by the whole building area of 56310 square meters, the annual energy consumption of per unit area 133 KWh/(m2a). Based the above results, it can be concluded that the annual energy consumption is consistency with the actual operation of the library. Computer rooms, reading area and offices in account for the total construction area of more than 70%, while the lighting requirements of these three functional areas are similar. Therefore, we change the lighting power density in these three functional areas instead of corridors and stairs areas. The simulation results for the five cases are showed; it can be obtained that with the increasing of lighting power density, annual energy consumption also increases apparently. Based on the different indoor personnel density, the simulation results of monthly electric consumption are presented. In summer, with the increase in personnel, air conditioning load increased which resulted in an increase of the energy consumption, while in winter; the result is just the opposite.



Summer indoor design temperature will directly affect the energy consumption of air conditioning system and building energy consumption. Fig shows the simulation results of annual energy consumption for different summer indoor design temperature. From the data in Fig, when the summer indoor design temperature increases, the annual energy consumption in buildings reduces.

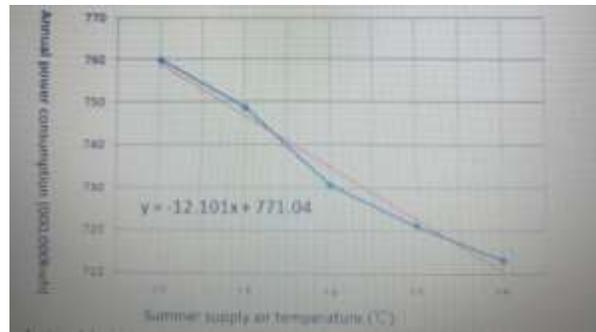
## 4. Discussion

The energy consumption of lighting equipment accounted for a large proportion in building energy consumption. Lighting power density will directly affect the energy consumption of air conditioning system and building energy consumption. Based on the simulation data, we can find the relationship between the annual power consumption and lighting power density in Fig. It can be seen that the trend line and the actual simulation data curve is similar. It is concluded that the lighting power density and annual power consumption exist in a linear relationship. It can infer that the annual consumption growth is about 10% when the lighting power density increases every 5W/ m2.



The number of indoor persons can affect heating and cooling load. Based on the simulation results, it can be found that there is a linear regression relationship between annual power consumption and indoor personnel density. As shown in Fig, it is obvious that with the increase of indoor personnel density, building annual energy consumption rises up. Summer indoor design temperature can affect the building cooling load. Higher the summer indoor design temperature is, less the building cooling loads. Fig shows how summer indoor design temperature affects the annual energy consumption.

It can be seen that the annual energy consumption of the building decreases along with the summer indoor design temperature increase.



Summer supply air temperature will directly affect the energy consumption of air conditioning system and building energy consumption. With the decrease of summer supply air temperature, electricity consumption of water pump and refrigeration rise up to some extent. Fig shows the relationship between the annual power consumption and summer supply temperature. It can be seen that there is a linear inverse relationship between the annual energy consumption and summer air temperature. It infers that higher summer supply air temperature can not only reduce cold discomfort, but also can help energy saving.

## 5. Conclusions

Office belongs to a kind of large public buildings, which is also the high energy consumption building. Among the building energy consumption, air conditioning system energy consumption accounts for the largest one which is 49% of the total energy consumption. Meanwhile, lighting and power consumption are 15% and 35% respectively.

We utilized control variables method to analyze the influence of four factors which are lighting power density, indoor personnel density, summer indoor design temperature and summer air supply temperature on building energy consumption. Lighting power density has a direct impact on the building energy consumption, and the influence is bigger. Summer supply air temperature on the degree of influence of building electricity consumption is greater than the summer indoor design temperature. Indoor personnel density mainly affects the load of air conditioning system in summer, and then influence the overall power consumption. According to the relevant provisions of green lighting, lighting power density for office room and other rooms is 9 W/ m<sup>2</sup>, and it shall not exceed 11W/ m<sup>2</sup>. Lighting equipment design for this kind of building should not exceed the specified value. According to the simulation results, we recommend that 0.93W/Sq ft (10W/m<sup>2</sup>) is more reasonable. Summer air supply temperature has influence on the power consumption. Higher each degree of summer air supply temperature, less 2.7% of the power consumption. In the premise of meeting the design requirements of the indoor air temperature, it can be appropriate to improve supply air temperature used by the automatic control system. It can enhance the operating efficiency of air conditioning systems and reduce the high load operation of energy. Building energy research and design of building energy saving and reconstruction is a long and hard process. It needs continued more delicate and more in-depth research. This paper just aims at the effects of four single variables on power consumption investigated, due to the limitation of time and ability, so more complicated work will be conducted in future. It is recommended to do multiple variables simulation and explores the influence of match among the variables on building electricity consumption.

## References

1. <https://www.doe2.com/equest/>
2. <https://energy-models.com/what-is-energy-modeling-building-simulation>

## Team Members

Name	Roll No.	Semester	Year	Branch
Abhishek Nag	17EGJCE004	8 <sup>TH</sup>	4 <sup>TH</sup>	CIVIL
Shubham Sharma	17EGJCE033	8 <sup>TH</sup>	4 <sup>TH</sup>	CIVIL
Sumit Yadav	17EGJCE034	8 <sup>TH</sup>	4 <sup>TH</sup>	CIVIL
Vishal Singh	17EGJCE037	8 <sup>TH</sup>	4 <sup>TH</sup>	CIVIL
Yash Singh	17EGJCE038	8 <sup>TH</sup>	4 <sup>TH</sup>	CIVIL

