Electrical Lighting Load Estimation Prior to Design

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Abstract

Electrical load estimation in the preliminary design level is critical prior to real design. To avoid a guess work, a reliable estimate is very important. This work assesses lighting estimation load base on scientific approach. The focus of this conference paper is to solve problem of engineering undergraduates, new engineering graduates or experience-acquiring engineers in the estimation of a new electrical lighting load requirement of a project edifice, especially an auditorium lecture theatre or hall. Data of existing lighting designs by undergraduates and post graduate students under the supervision of a leading author of this work were used to establish actual lighting load. The data collected is from 2014 to 2019 projects. The actual designs are five in numbers namely: 1000 Seat Lecture Hall, Multipurpose Hall Building, TI Francis Hall, Oluremi Event Centre and Event Centre (un-named). To estimate the lighting load, area of the space was obtained from the actual design to determine the corresponding lighting power allowance. Also, the total lighting design wattage of the space were extracted from the actual design and compared with the estimated lighting wattage. The results show that estimated lighting power prior to design is greater than the actual lighting design which in agreement with international standards. Also, the area of the building is proportional to the lighting estimated power required. 50% to 80% estimated lighting demand load is established in this work in accordance to international standards. 80% estimated lighting demand load is on very high side and that 65% estimated lighting demand load is preferred to 80% for a similar project work. This work will help undergraduates, new graduates and even post graduates in theory- practical oriented task application in reliable scientific and economic lighting load estimation.

Keywords: Lighting-Load, Estimation, Design, Hall, Scientific-approach

1 Introduction

Lighting energy is essential to the development, educational and economic growth including standard of living of any country (Oyedepo, 2012, Pritchard, 2014). Lighting is either artificial or natural, at times both may be combined to achieve practical or aesthetic purpose (Zumtobel, 2011). Electrical designer needs to determine the load requirement of a space with reference to the task to be performed. This load requirement is best calculated using proper or real design base on standard design criteria of international standards and at times, local standards in addition (Hickey, 1999). The Design criteria of code standards are necessary for effective design in term of functionality and cost effectiveness (Steven and Craig, 1998; Hickey, 1999).

Load estimation in the preliminary design level is critical prior to real design. The motivation of this conference paper is to solve the problem being experienced by undergraduate, new engineering graduates, Post graduates and experience-acquiring engineers to assess new electrical load requirement of an edifice. From experience, scientific preliminary load estimation is not adequately covered in their syllabus. The leading author was one of the victim in preliminary load assessment of a project in an interview 20 years ago. Preliminary load assessment of a project prior to design is a field which is largely a function of experiences. Since young graduate (1st and 2nd Degree) should fit into the employment needs of their prospective lighting employer bias of guessing, to avoid a guess work, a reliable estimate is very important. Hence this conference paper title Electrical Lighting Load Estimation prior to design is established. This load estimation is realistic load estimate or best possible estimated load since design load is not yet done. It therefore means that it is highly useful during preliminary design state of the project (Hickey, 1999).

Data of existing lighting designs by undergraduates and post graduate students under supervision of the leading author were used to establish actual lighting design. The data collected is from 2014 to 2019. The actual designs are five in numbers namely: 1000 Seat Lecture Hall, Multipurpose Hall Building, TI Francis Hall, Oluremi Event Centre, Event Centre (un-named). (Oyeleye and Akanni, 2019) used lumen per watt method to calculate the number of luminaries required for a space in building design. Also, utilization factor and maintenance factor of 0.65 – 0.7 and 0.8-0.85 is used respectively in their work.

This work focus on electrical lighting design estimation of Lecture Theater (LT) and Multipurpose Hall building (MHB)/ Event Centre (EC). LT and MHB are not directly covered by ASHRAE/IESNA (Hickey, 1999). The corresponding space activities is considered in this research as Junior/High school.

1.1 Load Estimates

According to Hickey, 2019, there exists five load estimates which include preliminary estimate, early design estimate, National Electric code (NEC) compliance estimate, energy compliance and final load estimate. The final load estimate is based on final design load requirement. The modified International Standards of American society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) and Illuminating Engineer Society of North American (IESNA) for lighting power allowance for each building is presented in Table 1.

Table 1 Prescriptive Unit Lighting Power Allowance, ULPA, (Watt/ Meter Square) Gross Lighted Area of Total Building (Adapted from Hickey, 1999: ASHRAE/IESNA 90.1-1989)

Space Task	0 to185.81 (m^2)	185.90 to 929.03 (m^2)	929.12 to 2322.58 (m^2)	2322.67 to 4645.15 (m^2)	4645.24 to 23225.75 (m^2)	> 23225.75 (m^2)
Office						
	20.44	19.48	18.51	17.75	16.89	16.14
[redacted]						
High School						
	20.44	20.44	20.23	19.69	18.94	18.29

Table 1 gives estimated connected load. For estimated actual demand load, a demand factor which is a function of experience will be applied. However, the experience may vary from one person to another. To avoid this variation, 50-80% demand factor (Hickey, 1999) is applied in this work. The application of 50-80% demand factor will yield estimated power requirement which corresponds to final estimated demand loads (Hickey, 1999).

1.2 Definition of Terms

The following terms are defined for proper understanding of this research work.

Load: is an electrical rating of any appliance connected to power supply.

Connected Load: it is the sum of equipment continuous rating tied to the power source.

Power Allowance: amount of energy that is acceptable or safe for use, estimate or design.

Maximum Demand: is the highest load demand during a period of time. The lighting loads varies with time which is a function of the task performed in the space.

Demand Factor: is the ratio of the maximum demand to the connected loads.

1.3 Hall, Event Centre, Office and School

Hall: an edifice or large chamber for public events such as meetings or dances.

Event centre: a large space that may be used for corporate events and parties. The corporate event may include businesses, examination, interview, and conference (Oyeleye, 2019).

Office: a building owns by organization with room where people can work at desk. (Oyeleye and Akanni, 2019).

Junior/High school: a place children are taught excluding pre-school, elementary, technical and vocational schools. (Hickey, 1999).

2. Methodology

The methodologies involve collection of data and application of appropriate equations for the required lighting load estimation in this research.

2.1 Data Collection

Required data were collected from reliable sources.

2.1.1 Actual Lighting Designs

Data of existing lighting designs by undergraduates and post graduate students under supervision of leading author were used to establish actual lighting design. The data collected is from 2014 to 2019. The actual designs are five in numbers namely: 1000 Seat Lecture Hall, Multipurpose Hall Building, TI Francis Hall, Oluremi Event Centre, Event Centre(un-named).

2.1.2 Area and Wattage of the Space

To estimate the lighting load from the actual design, the area and the wattage of the space were extracted from the actual design. Equation (1) was used to calculate the Area of the space, A_s, and Equation (2) was used to calculate the lighting wattage, L_w, of the actual design.

$$A_s = \sum(A_1 + A_2 + A_3 \dots A_n) \qquad (1)$$

Where A is the area of a defined space in the building and n is the last defined space in the building.

$$L_w = \sum[(L_r x\, N_L)_1 + (L_r\, x\, N_L)_2 + (L_r\, x\, N_L)_3 + \cdots (L_r\, x\, N_L)_n] \qquad (2)$$

Where L_r is Lamp rating; N_L is the number of luminaries in each of the defined space and n is the last defined space.

2.2 Load Estimation Prior to Design

To estimate the electrical lighting loads prior to design, Table 1 which consists the area and Lighting Power Allowance (LPA) was used to determine the LPA required for specific Area. From Table 1, the task used in this research is Junior/High school because all the designed building is a function of Junior/High school. Therefore, Junior/High school corresponds to Event center, Multipurpose Hall or Lecture Theater in this work. Also, total area of the existing building design was determined and compared with Table 1 to determine the corresponding lighting power allowance. The Estimate Lighting Power (ELP) was computed using Equation (3).

$$ElP = A\, x\, LPA \qquad (3)$$

Where A is the Area of a space and LPA is the lighting power allowance.

2.3 Application of Demand Factor

To obtain estimated demand load, demand factor of 0.5 to 0.8 was applied (Hickey, 1999). Equation (4) was used to obtain estimated demand load.

$$E_{Dl} = ELP\, x\, D.F \qquad (4)$$

where D. F is a demand factor.

2.4 Evaluation of Actual Lighting Design and Estimated Lighting Design

The results of the actual design and estimated design were plotted on the graph to determine the variation in the proposed method used in this work. This is done using Microsoft excel Software.

3. Results and Discussions

3.1 Results

The space with the task to be performed, the area of the space, the design wattage, corresponding lighting power allowance (LPA) to the space area, estimated connected load, estimated demand load of 0.5 and 0.8 were presented in Table 2.

Table 2 Lighting Power Design, Connected Load and Demand Load Estimate of Buildings

S/N	SPACE WITH THE TASK TO BE PERFORMED	AREA (m^2)	LPA (w/m^2)	DESIGN POWER (Watt)	ESTIMATED CONNECTED LOAD(Watt)	MINIMUM. ESTIMATED DEMAND LOAD (0.5)	AVERAGE ESTIMATED DEMAND LOAD (0.65)	MAXIMUM ESTIMATED DEMAND LOAD (0.8)
1	1000 Seat Lecture Hall	718.7	20.44	6478	14690	7345	9549	11752
2	Multipurpose Hall Building	1198	20.23	7806	24236	12118	15753	19388
3	TI Francis Hall	688.7	20.44	3858	14077	7039	9150	11262
4	Oluremi Event Centre	756.72	20.44	4919	15467	7734	10054	12374
5	Event Centre Hall	449.7	20.44	3789	9192	4596	5975	7353

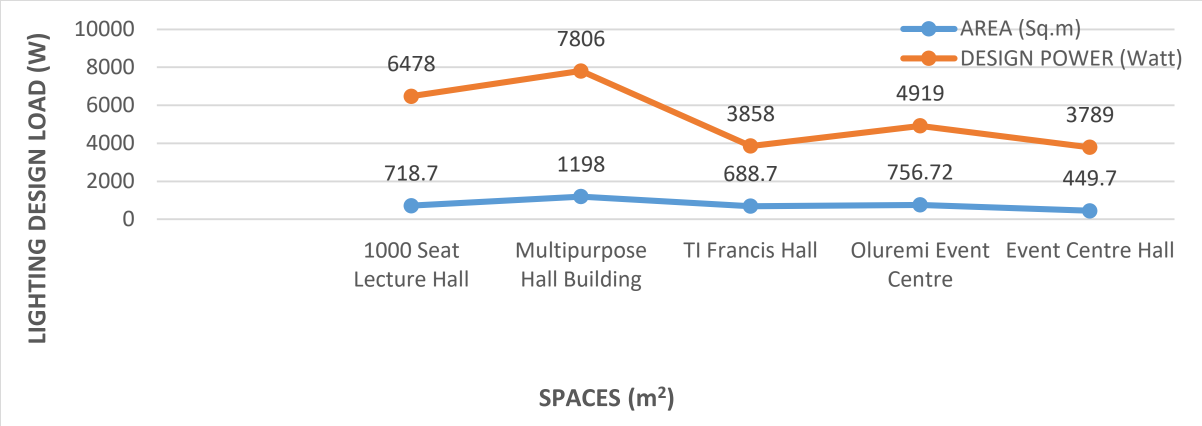

Figure 1 Area of Building against Design Wattage

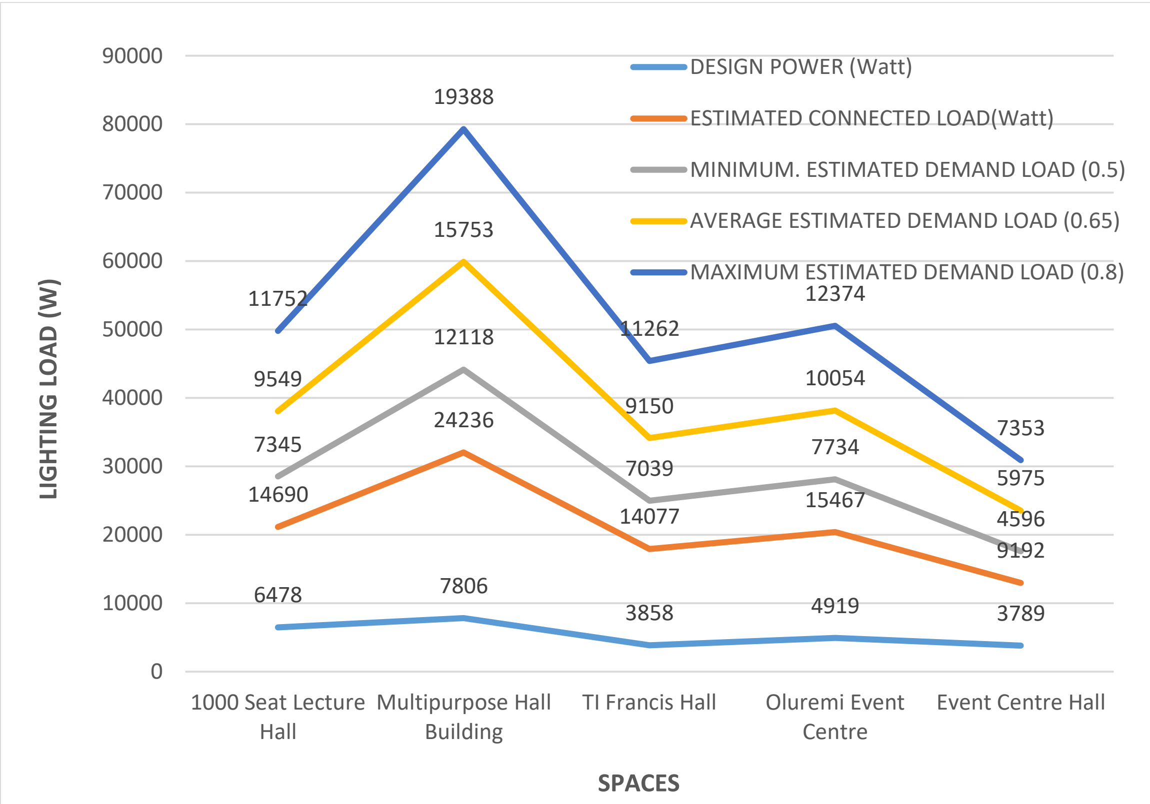

Figure 2 Design Load versus Estimations

3.2 Discussion

From Table 2, five task spaces were considered. The characteristics of this spaces are similar. There similarity is in conformity with the Junior/High School (Table 1) and Event Center/ Multipurpose Hall/ Lecture Theater (Table 2). From Table 2, Figure 1 and Figure 2 are produced for clarity. From Figure 1 and Table 2, the area of the building is not proportional to the design wattage. This is due to the fact that the component of each building in term of task to be performed varies from one building to another. Also, the space with the task to be performed varies with the design power.

From Figure 2, estimated connected load for the designed building is greater than the actual design. This means that the result is in conformity with the standard (Estimated Value) used in this research. However, this estimated connected load is very high to the actual design. On introduction of demand factor of 50% (Minimum), 65% (Average) and 80% (Maximum), it was noted that the 80% result is the highest; 65% is higher while 50% is the minimum. The 50% estimation demand load is the closest to the actual design value; while 80% is on very high side.

4 Conclusions and Recommendations

The conclusions and recommendations are as underneath.

4.1 Conclusions

i. This work eliminates a guess estimation and welcomes a scientific approach lighting estimation prior to real design.
ii. The estimated lighting power prior to design is greater than the actual lighting design.
iii. The area of the building is proportional to the lighting estimated power required.
iv. 50% to 80% estimated lighting demand load is established in this work in accordance to international standards.
v. 80% estimated lighting demand load is on very high side.
vi. 50% estimated lighting power requirement is the closest to the actual lighting power design.
vii. 65% estimated lighting demand load may be preferred to 80% for a similar project work.

4.2 Recommendations

i. This work will help undergraduates, new graduates and even post graduate in theory-practical oriented task.
ii. 65% estimated lighting demand load is recommended for related work.

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