Lighting Installation with Enhancement in Illumination Effectiveness

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Abstract—**This project present the design of lighting system where the most important management in a specific location that is located in a building such as a classroom. This project focused on illumination effectiveness since lighting reports for major of electricity consumption. Significant cost saving can be achieved with enhancement in illumination effectiveness. Thus, this project helps users to minimize their electricity usage according to lighting design in a classroom. As results, users are able to determine the saving cost, voltage drop and the minimum lamps needs for lighting installation without reduce the quality of illumination at that place.**

Keywords-illumination effectiveness; luminaries; lighting design; lighting quality; voltage drop

I. Introduction

Light is a flow of energy. Like radiant heat, radio waves and X-rays, it is part of the electromagnetic spectrum and can be described in term of wavelength and power. Light can be mixed from many colours and there is no one to one link between the spectral distribution of radiation and human perception of brightness and hue [1]. For this reason, light is defined uniquely by the response of the human eye. It has its own set of units, which allow it to be quantified and which are linked to other units of power such as Watts (W).

There are several factors that affect lighting performance such as paint colours, reflection factor, maintenance factor and utilization factor [2]. Lighting condition is very important to every building because to be giving a good illumination source to each of classroom [3].

Lighting design is more than the selection of luminaries. Its scope is the composition of brightness and colour across the whole visual field. How a space is perceived or how a visual task is accomplished depends not on illumination only but on its interaction with the enclosing form of the classroom, colour and surface texture [4].

It is necessary considering the lighting equipment to ensure efficient conversion of the electricity into light, by selecting lamps that are appropriate for the purpose and have a high efficacy. Usually this means using discharge lamps that have efficacies if at least 50 lm/W [5]. It is also important to use luminaries that produce a high proportion of the lamp light output which direct the light to the targeted area. This implies the use of luminaries that have a high light output ratio and an appropriate intensity distribution. Efficiency can be assessed by a luminary's utilization factor, although this applies only when fittings are used in a regular array [6].

Installation design for good energy usage begins by ensuring that lighting is not spread unnecessarily [7]. For example, much lighting in commercial building has in the past been provided by regular arrays of ceiling-mounted luminaries which giving uniform illuminance over the classroom.

There are several strategies available to minimize electricity requirements in a classroom. For example, specify of illumination requirements for each given area. Second strategy is analyzed of lighting quality to ensure that adverse components of lighting (such as glare or incorrect color spectrum) are not biasing the design. Third strategy is the integration of space planning and interior architecture (including choice of interior surfaces and area geometries) to lighting design. Next strategy is design of time of day use that does not expend unnecessary electricity. Besides that, the selection of fixture and lamp types that reflect is best available technology for electricity conservation.

II. Types of Lamp

A. Fluorescent Lamp

The most common application of this technology is in tubular fluorescent lamps. The standard fluorescent tube has a diameter of 38mm [8]. Lately, such lamps are available in both circular form as well as compact fluorescents utilizing folded tubes of much smaller diameter.

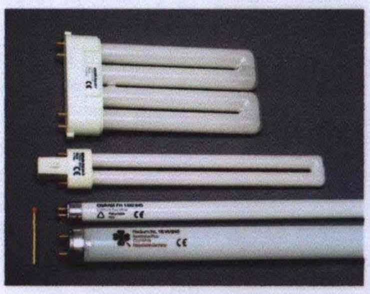

Figure 1. Fluorescent Lamp

B. *Incandescent Lamp*

An electric current passing through the wire heats it to incandescent and the wire emits light. The filament wire (shown in Figure 2) diameter and length determine the amount of electrical current drawn by the lamp, regulating its light output [9].

Each incandescent lamp contains a filament, which is more or less centered within the bulb. A filament is a length of tungsten wire. Tungsten is used because of its high melting temperature.

Filament design is determined by striking a balance between light output and lamp life [9]. It is a function of filament temperature. The higher the temperature at which the filament operates, the more light it emits and the shorter its life. A long-life lamp of a given wattage consumes the same current but is designed for a shorter life.

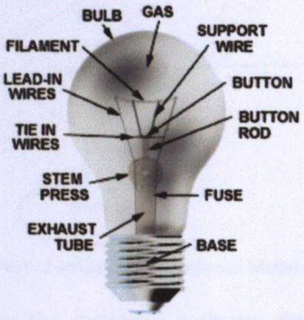

Figure 2. Incandescent Lamp

C. *High Intensity Discharge (HID) Lamp*

HID lamps consist of an arc tube enclosing two electrodes and one or more metals that are vaporized and ionized to conduct current in an electric arc from one electrode to the other [9]. When a lamp is energized, an electric field is established between the starting electrode and the main electrode, causing individual particles of the starting gas to become electrically charge.

HID commonly used to designate four distinct types of lamps that actually have very little in common [10]. They are high pressure sodium, low pressure sodium, metal halide, and mercury vapor. Each requires a few minutes to come up to full output. In addition, if power to the lamp is lost or turned off, the arc tube must cold to a given temperature before the arc can be re-struck and light produced.

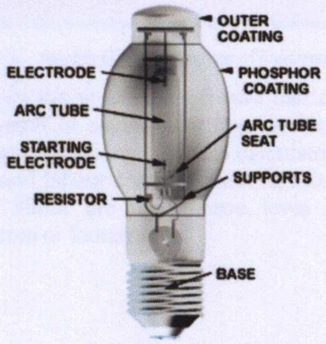

Figure 3. High Intensity Discharge (HID) Lamp

III. Methodology

Figure 4 shows flowchart of Matlab GUI programme. Firstly, an existing GUI will open and a new GUI from one of the GUIDE templates was chosen. After that, all the required components are created in the component palette. Then, it is need to save the figure. Then, the GUI is activated.

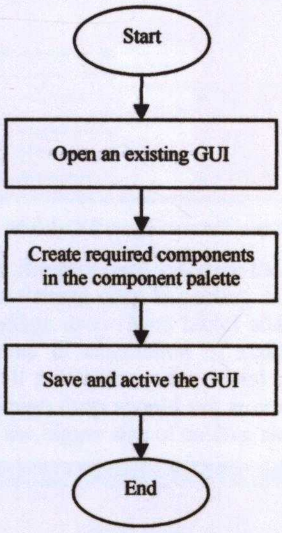

Figure 4. Flowchart of Matlab GUI programme

In this project, the proposed software program is divided into three parts. The first part is Number of Luminaries that will allow users to determine the amount of luminaries for the classroom. It is important to obtain the best illuminance lighting in that classroom and at the same time minimizing the electricity.

Users just need to enter the required data or parameters. Then, click the "Calculate" button. Next, the program will display the amount of luminaries needed for that specific area. Second part is Lamp Replacement that focused on enhancement in illumination effectiveness. It starts with the initial design, and then the new design was proposed for the lamp replacement. Software proposed for lamp replacement is an electricity efficient lighting system that will reduce the cost, without reducing the quality of lighting system. The third part is Voltage Drop that can help users to determine the actual voltage drop in cabling of design lighting. Therefore, the best cabling with a smaller amount of voltage drop will be choosing in cabling of lighting design.

Flowchart in Figure 5 shows the step on how to run the proposed software. Firstly, the user should know the required parameters and insert the data into the box given in the software. Next, the users need to press the "Calculate" button to execute the program. Then, the software will calculate all the assigned parameters and displayed the results in the box. Besides that, if the user still wants to run the program, pressing the "Reset" button, will clear all the parameters. Then, the user just needs to follow the step as before.

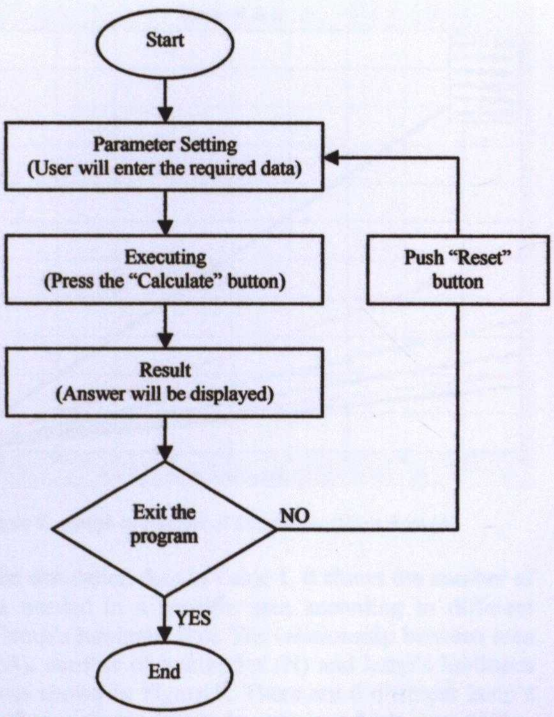

Figure 5. Flowchart of designing the proposed Matlab GUI programme

Figure 6 shows the proposed software that can used to calculate the number of luminaries needed in the classroom. Besides that, it also will show the user about the room index, maintenance factor and utilization factor of a room.

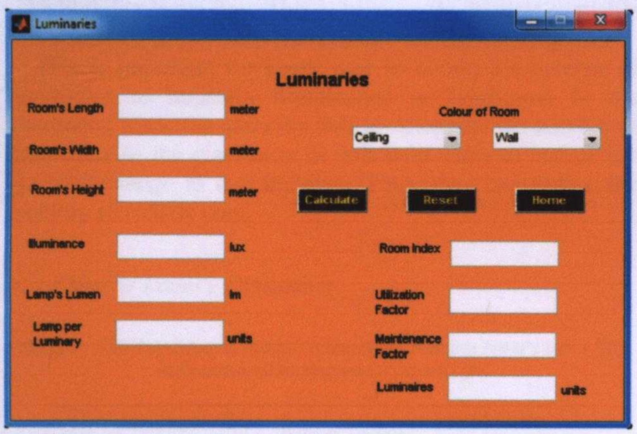

Figure 6. Matlab GUI programme of Luminaries

Figure 7 shows the proposed software that can be used to calculate the amount of saving cost that can be achieved per annum. The amount of saving cost was calculated according to electricity, tube and labour costs. Moreover, this software also shows the user about the illuminance level in that room, whether it decreases or increases.

Figure 7. Matlab GUI programme of Lamp Replacement

Figure 8 shows the proposed software that can be used to calculate the actual voltage drop in cabling of lighting design. Current design, voltage drop (from table) and length of cable should be considered in calculation of actual voltage drop. After considering all above, the value actual voltage drop will get. The actual voltage drop should not exceed 4% of supply voltage. If exceed, the bigger size of cabling should be used.

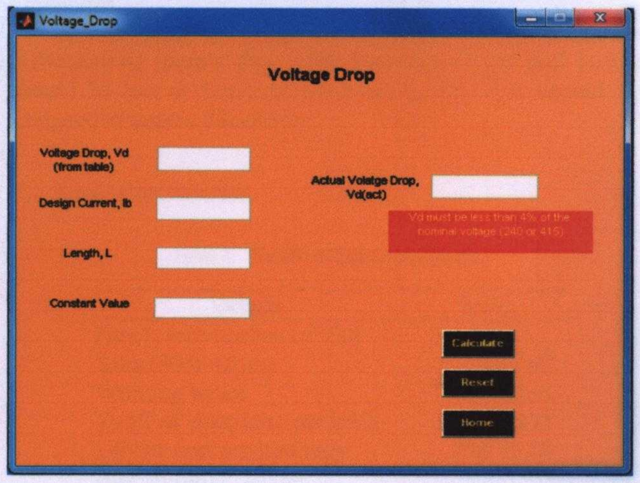

Figure 8. Matlab GUI programme of Voltage Drop

IV. RESULTS AND DISCUSSIONS

A. *Effect of Lamp's Luminous Flux*

Table 1. Tabulated data to identify relationship between area (A), lamp's luminous flux (F) and number of luminaries (N)

Area, A (m^2)	Luminous Flux, F (lm)	Luminaries, N (units)
25	500	25
40	1000	20
50	1500	18
65	2000	18
80	2500	18
100	3000	18

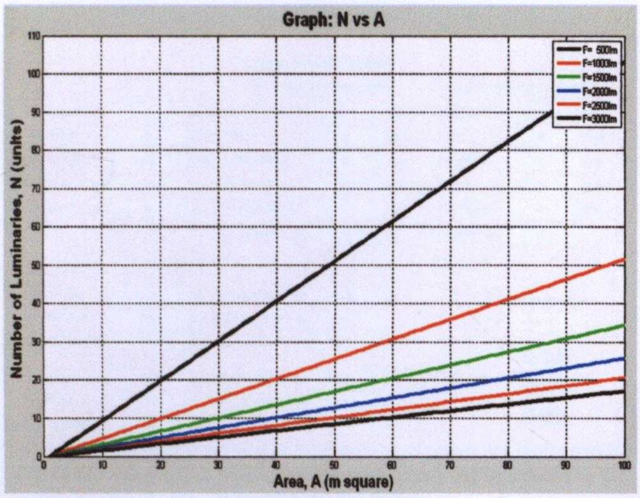

Figure 9. Graph of Number of Luminaries (N) vs Area (A)

From the simulation data in Table 1, it shows the number of luminaries needed in a specific area according to different values of lamp's luminous flux. The relationship between area of room (A), number of luminaries (N) and lamp's luminous flux (F) was shown in Figure 9. There are 6 different lamp's luminous flux values shown in graph, which are 500lm, 1000lm, 1500lm, 2000lm, 2500lm and 3000lm.

From the graph, it shows that the numbers of luminaries are proportional to the area where if the area increases, then the numbers of luminaries also increase. Here, users can reduce the number of luminaries in a classroom by using the lamp with high luminous flux. This is because the highest available luminous flux in the lamp will provide the highest brightness.

This is important for every user to obtain the number of luminaries to maintain illuminance or brightness in the classroom. Since the users are able to determine the number of luminaries in the classroom, it will help users to reduce the electricity usage in that building. Thus, they can reduce the monthly electricity cost.

B. *Effect of Room's Dimension*

Table 2. Tabulated data to identify relationship between room's index (RI) and number of luminaries (N) at area (A)

Dimension, L×W (m×m)	Room Index	Luminaries, N (Units)
10×10	2.08	18
12.5×8	2.03	18
20×5	1.67	20
25×4	1.44	22
50×2	0.80	29

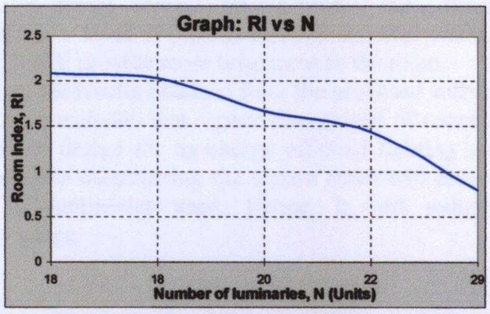

Figure 10. Graph of Room's Index (RI) vs Number of Luminaries (N)

The graph above shows the relationship between room index (RI) and number of luminaries (N). It shows that the room index is disproportional to the number of luminaries.

Table 2 shows the effect of room's dimension to the number of luminaries. For this case, the area of the room was set to 100m^2, but the dimension of the room can be various. From the tabulated data, it shows that if the difference between the length and width were large, the value of room index would be small. Hence, it will increase the number of luminaries.

Thus, in order to reduce the number of luminaries, the difference of room's dimension (between length and width) should be less or same. In other word, the room should be designed in square dimension.

C. *Lamp Replacement*

Table 3. Details of lamp replacement

Details	Units
Part 1: Information of Hall	
Area (30m ×20m)	600 m^2
Working hours	15000 hours
Tariff of electricity per kWh	RM 0.23
Labour cost per luminary	RM 15.00
Part 2: Initial Design	
Lamp life rating	10000 hours
Power of lamp	27 W
Lamp efficacy	48 lm/W
Luminaries	40 units
Lamp per luminary	2 units
Lamp price	RM 10.00
Part 3: New Design	
Lamp life rating	10000 hours
Power of lamp	36 W
Lamp efficacy	72 lm/W
Luminaries	25 units
Lamp per luminary	2 units
Lamp price	RM 15.00

Figure 11. Matlab GUI programme shows that costs can be reduced by the suggested lighting design

Table 3 shows the example of data replacement worksheet. It consists of the specification of the room, the overall costs (such as labour cost and tube cost), requirement of initial lighting design and proposed lighting design for the room. Figure 10 shows the result of cost saving that can be achieved by replacing the initial lighting design with the proposed lighting design.

From the result obtained, it shows that the main factor that can lead to the cost saving is the characteristics of the lamp (such as electrical input, lumen and lamp efficacy). All factors are important to be considered in order to minimize the operating costs.

Different electrical input is required for different lamp that is depends on the lamp's lumen. If the lumen is increased, the amounts of electrical input also increased. In fact, the lamp manufacturers assigned the lamp's electrical input.

Lamp efficacy is also important in order to reduce the number of luminaries. Lamp efficacy refers to luminous efficacy. Luminous efficacy is a figure of merit for light sources. It is the ratio of luminous flux (in lumens) to power (in watts). As most commonly used, it is the ratio of luminous flux emitted from a light source to the electric power consumed by the source, and thus describes how well the source provides visible light from a given amount of electricity.

V. CONCLUSION

In this project, the main objective is to minimize the number of luminaries in a specific room with enhancement in illumination effectiveness was succeeded. Besides that, the advantages of illumination effectiveness in terms of minimizing the operation costs were analyzed.

It is important to minimize the electricity usage because it will minimize the monthly expenses of electricity bill. Besides that, it is important to choose the best lighting specification for a certain room. This is because to avoid any problem such as eye trouble (become dim).

It can be concluded that, the ideal specification of lamps for best lighting design depends on the rooms' size, dimension and illuminance level. If there is more lumen that available in the lamp, it will provide more brightness to the room.

Based on the results obtained from the proposed software, it also can be concluded that square dimensions of room is the most suitable design for an energy efficient lighting system. This is because constructing the square room will reduce the number of luminaries used. Hence, it will reduce the electricity usage.

VI. FUTURE DEVELOPMENT

In order to achieve more cost saving, this project should be continued further. For example, analyze the illumination effectiveness according to lighting control systems such as dimmer and wireless sensor.

Dimmer is a device that can be used to vary the brightness of lamp. By decreasing or increasing the voltage, it is possible to vary the intensity of the light output. It shows that the dimmer can be use to manage the electricity in the buildings. Thus, it will contribute to the amount of cost saving.

Sensor is a device that measures a physical quantity and converts it into a signal that can be read by other instruments such as photo sensor. This device also can help people to control the electricity efficiently. It can be used to control the lamps whether to switch on or off at the suitable time. For example, the lamps will be switch on during the night.

As a result, the usage of dimmer or sensor in the lighting control system will provide more in lighting efficiency. Hence, it will reduce the electricity cost and manage energy efficiently.

VII. ACKNOWLEDGEMNET

The author would like to express his deepest appreciation to his supervisor Assoc. Prof Dr. Noraliza Hamzah for very useful suggestion, guidance, and advice for the completion and success of this project. The author also would like to convey his appreciation to all the people that help and contribute any ideas in realizing his project.

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