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Development of A Microsoft Excel Based Energy Saving Calculator for Industrial Lighting

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ABSTRACT: The concept of energy saving has secured the attention of everyone. Every design engineer has continued to step up his art of developing energy saving technologies while consumers and industrial operators are acquiring them to conserve their hard earned resources. Lighting systems are those devices that are found everywhere and it has been established that ample electrical power generated globally annually are expended on them. The paper explains the use of Microsoft Excel to develop the energy saving calculator which estimates power consume by inefficient lighting and energy saving lighting units. It calculates the units of energy in kWh saved in a day, in a month and in a year. It determines saving in a year. It employs the knowledge of the cost purchasing the bulbs including the discount given to determine the payback on investment on installing the lighting units in years. The calculator automatically plots bar charts of the energy saved before and after the replacement of inefficient units by energy efficient units types. It recommended the usage of LED lightings going by their advantages.

Keywords — Efficiency, Energy, Excel, Calculator, Industry, LED, Lighting, Payback

I. INTRODUCTION

Industrial processes require good illumination in order to produce quality product [1]. No one will want to buy inferior items in the market, thus, all human crave for the best. The foregoing cannot be attained without painstaking deploying industrial efforts geared towards putting action plans in place in order to reduce defects. No wonder quality checks in auditing zones do punctuate all production lines. An important aspect of production is good illumination. Thus, a lot of energy generated globally is used to power lighting units. It is said that about 15% of the world's electrical energy is used for lighting energy [2]. With emergence of LED technologies and compact fluorescent tubes, a lot of energy is being saved globally. Energy efficiency is the goal of efforts to reduce the amount of energy required to provide products and services. For example by installing fluorescent lights reduce the amount of energy required to attain the same level of illumination compared to using traditional incandescent light bulbs. CFLs and LEDs use 25% to 80% less energy and may last 3 to 25 times longer than incandescent lights [3]. Improvements in energy efficiency are most often achieved by adopting a more efficient technology or production process. There are various motivations to improve energy efficiency. Reducing energy use reduces energy costs and may result in a financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy efficient technology. Reducing energy use is also seen as a key solution to the problem of reducing greenhouse gas emissions. According to the International Energy Agency, improved energy efficiency in buildings, industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases [4]. Energy efficiency has proved to be a cost-effective strategy for building economies without necessarily growing energy consumption

II. METHODOLOGY

An engineer who is non programmer, armed with good knowledge of MS Excel can deploy one or two tricks to solve his technical problems [5]. The method used was itemization of calculations to be done and deployment of excel functions to achieve them. A TODAY () function was used to returns the current date. It allows the calculator to show the current date on its application screen. Arithmetic operations were done to do multiplications (*), subtraction (-) and divisions (/). The use of IF logical function was employed to calculate payback years after determining if there was replacement done or not for example, =IF(G26<=0,"No Replacement",G28*G12*(1-G30/100)/G26) means

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test if cell G26 is less or equal to zero, if true, print: "no replacement", if false, that is, a replacement was done perform this arithmetic operation G28*G12*(1-G30/100)/G26 and return the value in the cell. The gridlines were set in the advanced excel option not to show. Cells and formulas were protected from being inadvertently deleted by pass wording them. Only cells whose values can be changed were allowed without password.

III. ENERGY EFFICIENT LIGHTING

An energy efficient lighting system will undoubtedly improve the energy saving capability of an Industrial enterprise thereby allowing the saved energy gainfully deployed to other electrical power consuming production processes in one hand and preventing losses expended on skyrocketed bills occasioned by inefficient lighting systems. In this case, careful design of lighting systems going by the tasks to be performed in each work-zone is priceless. Another consideration should be the consideration of the age of an individual who performs specific tasks in a work area. With emergence of LED technologies and Compact Fluorescent Lamps CFL, a lot of energy is been saved globally. LED is an acronym for Light Emitting Diode. It is a semiconductor device that emits light when electrical current is passed through it [6]. A Semiconductor device has its conduction level between a conductor and an Insulator, that is, two extremes. . A typical 12V, 6.5 W LED has reference number its luminous flux of 390lm with luminous intensity of 1250 Cd and average lifetime of 25000hours.

3.1 Terms for Lighting Systems' Design

An Engineer who ventures into lighting systems' design must be well at home on the following important definitions and terms, namely: luminous flux, illuminance, luminous efficiency and luminous efficiency.

1. **Luminous flux:** It refers to a measure of light being perceived by human [7], for a light source, its luminous flux is the measurement of the illumination it can contribute the work-zone, it is one the specifications of a lighting device that must be considered. To select which LED lamp to use, an engineer needs to understand the task at hand, amount of lumen to produce a particular amount of illuminance. Its unit is lumen (lm).

2. **Illuminance:** It refers to the measure of how luminous flux is spread over a given area or a measure of intensity of illumination on a surface, its unit is lumen per square metre. A work zone where visual tasks are only performed occasionally require 100lux while where visual tasks of high contrast is envisaged an 300lux illumination is needed [8].
3. **Luminous Efficacy and Luminous Efficiency:** Luminous Efficacy is a figure of merit for light sources; it refers to the ratio of luminous flux to the electrical power. That is, amount of brightness produced per power input. Luminous efficacy, in lumen per watt tells an engineer amount of lumen to be produced from each watt applied for a particular lighting unit. Its unit is Lumen per watt. While luminous efficiency is the ratio of the luminous efficacy to the maximum possible value of efficacy.

IV. AN EXCEL WORKSHEET

Every excel worksheet comprises of thousands of rectangles which are called cells. These cells are intersections of rows and columns [9]. While columns are identified by letters A, B,C and rows are identified by numbers 1, 2, 3,...Figure 1.0

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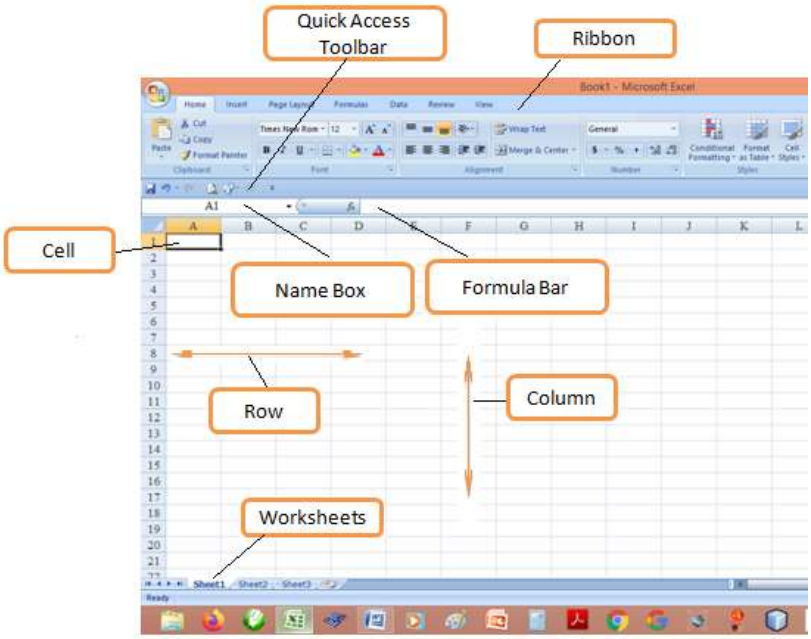

Figure 1.0: An Excel Application Window

V. STEPS FOR CALCULATING AMOUNT OF ENERGY SAVED THROUGH ENERGY EFFICIENT LIGHTING

The under-listed steps were used to develop the Energy Saving Calculator.

1. Number of working days in a month
2. Number of working days in a year
3. Power Consumption (w) Efficient Lighting
4. Power consumption (w) Inefficient Lighting
5. Replaced quantity
6. Calculate amount of energy saved (w)
7. Average daily use (Hours)
8. Electricity cost (₦/kWh)
9. Calculate Energy saving/type/day (kWh/day)
10. Calculate Energy saving/type/month (kWh/month)
11. Calculate Energy saving/type/ Year (kWh/year)
12. Calculate Total Energy saving/year (kWh)
13. Cost of Inefficient lighting
14. Discount %
15. Calculate Payback (years)

5.1 The Calculator

The calculator in figure 2.0 has five channels thus providing opportunity for comparing different scenario of replacements. The rectangular cells are the inputs, whenever all the required inputs are entered, the calculator calculates the energy saved per type in watts, energy saving per type per day in kWh, energy saving per type per month in kWh, energy saving per type per year in kWh, if the cost of purchasing the energy saving unit is entered in its field and the discount supplied, the payback in years will be calculated. The unit also plot a bar chart (Figure 3.0) thereby enabling visual appreciation of the acts of replacing inefficient lighting units.

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ENERGY SAVING CALCULATOR

No of working days in a month	20	12-Apr-21			
No of working days in a Year	184	1	2	3	4
Power Consumption (W) - Efficient lighting		5	15	18	22
Power Consumption (W) - Inefficient lighting		56	56	56	56
Replaced Quantity (PCS)		20	20	20	20
Saving /Type (W)		1020	820	760	680
Average daily use (hrs)		8	8	8	10
Electricity Cost Naira/KWh			50.66		
Energy Saving/Type/Day (KWh)		8.16	6.56	6.08	6.80
Energy Saving/Type/Month(KWh)		163.20	131.20	121.60	136.00
Energy Saving/Type/Year (KWh)		1501.44	1207.04	1118.72	1251.20
Total Saving/Year (Naira)		76062.95	61148.65	56674.36	63385.79
Cost Of LED Bu.b (Naira)		250.00	1000.00	1200.00	1300.00
Discount (%)		25	25	25	25
Payback (Years)		0.05	0.25	0.32	0.31

Figure 2.0: Energy Saving Calculator

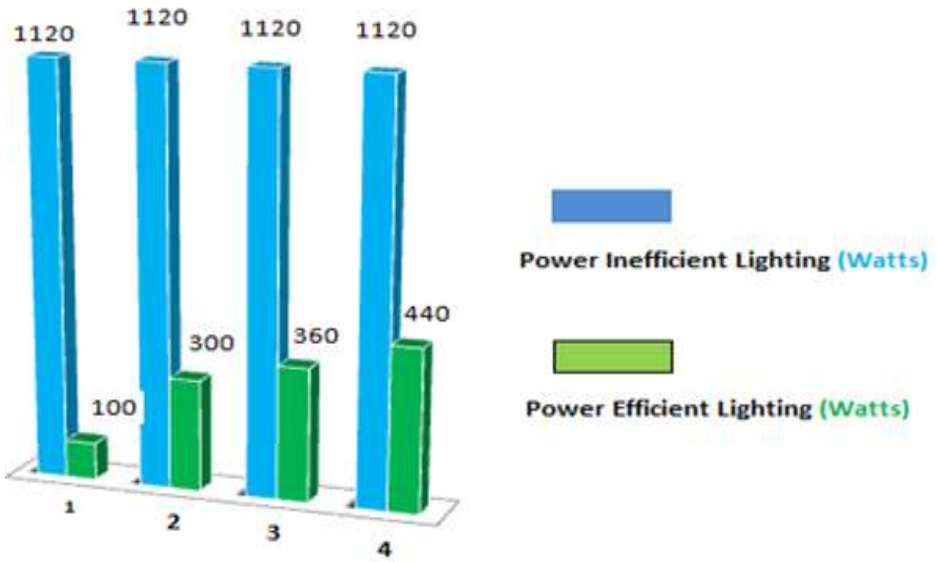

Figure 3.0: An Automatically Plotted Chart

VI. THE RESULTS AND DISCUSSION

Most industries work for twenty days in a month, in a year, two hundred and forty days, but by considering public holidays and maintenance planned shutdowns, working days are reduced. For example, typically One hundred and eighty four days are used [10]. In type 2, below, 20 units (I12) of 56W fluorescent fittings (I10) are to be replaced with 15W (I8) LED types. The saving recorded in cell (114) was calculated from (I12*(I10-I8). The energy saving per day in kWh calculated in cell I20 was obtained from I14*I16/1000, that is saving type in watts (I14) multiplied by average daily use in hour (I16) all divided by 1000 in order to have the unit in kWh. The energy saving per type per month is equal to I20*E4 (energy saving per day I20) multiplied by E4 (number of working days per month). The figure 4.0 below shows the formulas in cells instead of their calculated results.

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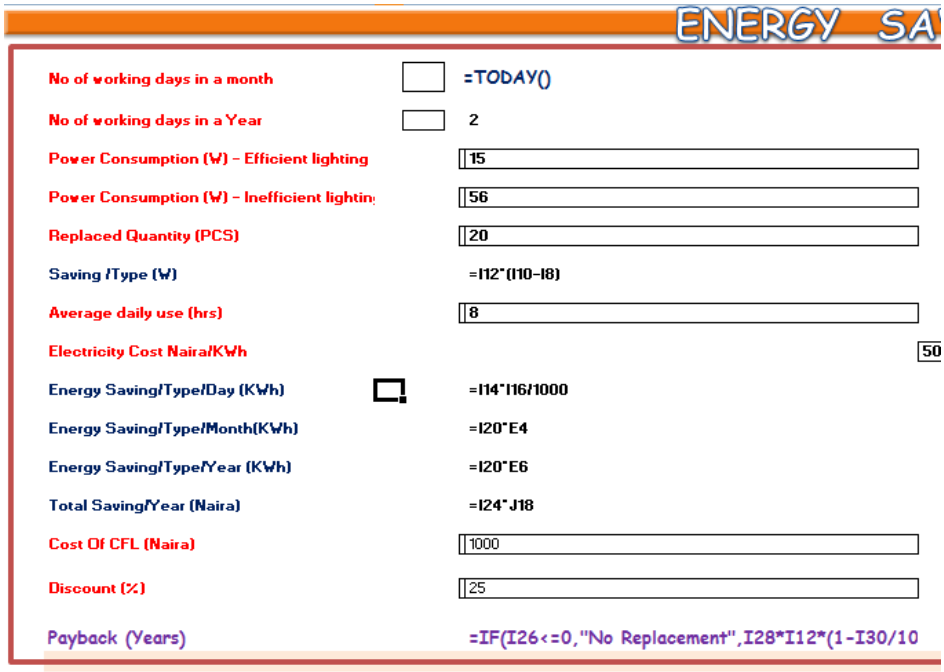

Figure 4.0: Formulas in Cells Instead of their Calculated Results

VII. CONCLUSION

In order to make the calculator look better in MS Excel environment, the gridlines, row and column headers, formula bars, sheet tabs and ribbons were set to be hidden. Also, the act of replacing lighting units must be done by considering the lumens of the inefficient units and ones to replace them Many times, new units are replaced without considering lumens per watts obtainable from the new units thereby expending more energy to power them thereby defeating the reasons while the actions are being carried out. LED lighting units are more reliable, provides instantaneous illumination; they have high lifespan with better lumens output per watts. [11]. It is not out of place to replace four units of incandescent bulb with just one lower wattage LED unit. A typical LED bulb of about 8 to 12w has brightness comparable to a 60W incandescent unit [12].

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