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Analysis and Study of Energy Efficiency in the Electric System of the Millennium Education Schools “SUMAK YACHANA WASI of Imbabura Province in Ecuador

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Abstract

This work was based on the energy consumption of the Millennium Education School SUMAK YACHANA WASI belonging to the province of Imbabura-Ecuador (UEM), the period 2017-2018 was taken into account like a reference, the data of electrical system was used to determine its demand, where it was evidenced that the highest energy consumption is the Lighting system. To obtain an improvement in the Electric system efficiency and specifically in the Lighting system, the replacement of fluorescent luminaires with LED technology luminaires is the best option. A financial analysis of the implementation was carried out, and the investment is recoverable, therefore, it is determined that the project is viable.

Keywords: *Electrical system, LED technology*

1. Introduction

Currently, petroleum is maintained as a primary energy source, however its derivatives such as diesel, gasoline and liquefied petroleum gas (LPG) have contributed to the development of humanity, the resources that are derived from petroleum are NOT renewable, additionally, the gases that are generated by combustion pollute the environment [1]. According to the effective power, the representative power plants in electricity generation are Hydraulics 58.53%, Thermal power plants 39.16%, Biomass 1.66%, Photovoltaic 0.32%, Wind 0.24%, these data are shown in the figure1. Renewable energies are those that are characterized by replenishing at a rate equal to or higher than those consumed, where we can cite the following: (i) hydraulic energy, (ii) Wind energy, (iii) Biomass energy, (iv) Biofuels energy, (v) Geothermal energy, (vi) Mareomotive energy, (vii) Photovoltaic energy, (viii) Concentrated solar energy. The development of the human being is based on the use of electric energy, currently in our country (Ecuador) [2], there is not a culture of energy efficiency or energy saving in the public sector, specifically in public schools. Since

National Balance of Electricity as of October 2019

		MW	%
	Hydraulic	5073,65	58,53%
	Wind	21,15	0,24%
	Photovoltaic	27,63	0,32%
	Biomass	144,3	1,66%
	Biogas	7,26	0,08%
Total Renewable Energy		**5273,99**	**60,84%**
	Thermal MCI	2010,92	23,20%
	Thermal Turbogas	921,85	10,63%
	Thermal Turbo steam	461,87	5,33%
Total Not Renewable Energy		3394,63	39,16%
Total Nominal Power		**8668,62**	**100%**

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the Millennium Education Schools(MES) are an emblematic project for the country, its have laboratories, classrooms, sports fields, which have a significant installed load 207.07KW, this work will be focused on the Lighting system where a potential energy saving was identified with the replacement of traditional technology (fluorescent) luminaires with LED technology luminaires like is shown in the figure 2, because the lighting system covers 13% of all installed load.

2. MATERIALS AND METHODS

Light is the kind of radiant electromagnetic energy capable of being perceived by the human eye Light sources are the main tools that audiovisual professionals use for their work and know how to broadcast or transform. Sunlight, is the total spectrum of electromagnetic radiation, meanwhile light ray is the imaginary line that represents the direction in which the

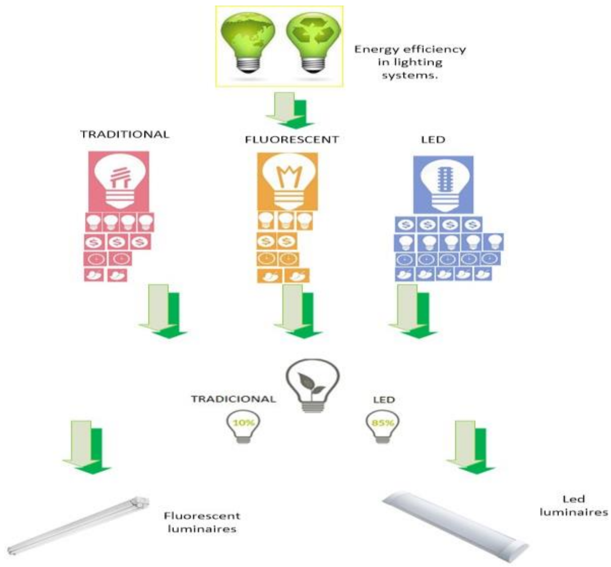

Fig. 2: Lamps Performance Comparison

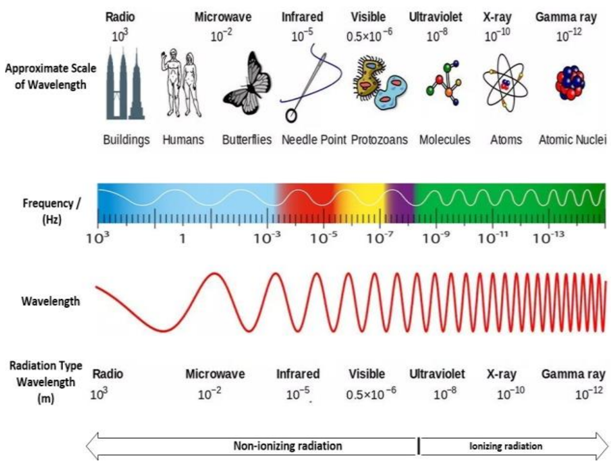

Fig. 3: Electromagnetic Spectrum light propagates [3].

The consuption is the amount of product obtained from a process per unit of energy. Set of activities aimed at reducing consumption through the proper use of energy in the current patterns of

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consumption our society is unfeasible [4]. The electromagnetic radiation is defined processes in which energy is emitted in the waves form or material particles and can propagate both through a material medium and in a vacuum, they differ from each other in the frequency value. The higher the radiation frequency, the greater its energy, covering a wide range of phenomena of different nature like is shown in the figure 3 [3], [5]–[7]. In the figure 6 the visible light is composed of radiation of wavelengths between 400 and 700 nm (4 · 10-7 and 7 · 10-7 m), millionth of a meter. White light is the sum of all these

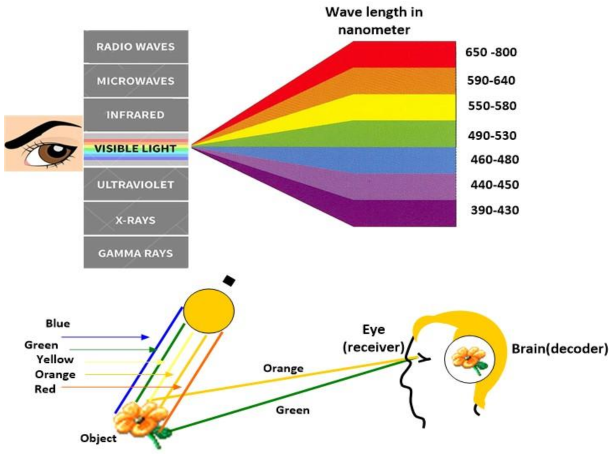

Fig. 4: Visible Spectrum

vibrations when their intensities are approximately equal. The sensitivity of the human eye depends on the wavelength and it has a maximum at 550 nm. Some people are able to perceive from 380 to 780 nm [3]. The evolution of the light going changing according to the human needs, from the beginning when the humans only used the sunshine to nowadays when is possible use the LED´s lamps. It was created for the purpose of lighting and work from electric light. Among them we find the following:(i)The incandescent light bulb (ii)Mercury bulb (iii) Sodium bulb (iv) Halogen bulb (v)LED bulb [3]–[5]. The incandescent light bulb works from a carbon filament which is passed an electric current, when it reaches such a high temperature that emits radiation (Joule Effect), creating lighting [3], [4]. Mercury bulb is a quartz discharge tube filled with mercury vapor, which has two main electrodes and an auxiliary one to facilitate starting. Emits greenish blue light, does not contain red radiation [3], [4]. Sodium bulbs it is composed by a gas discharge using sodium vapor to produce light. They provide a lot of lumens per watt. The color of the light they produce is bright yellow [3], [4]. Halogen bulb is an improvement of the incandescent lamp with a tungsten filament inside an inert gas and a small amount of halogen (such as iodine or bromine) [3].The filament and gases are in chemical equilibrium, improving the performance of the filament and increasing its useful life. The glass is replaced by a quartz compound, which can withstand the high temperature (482º F) [3], [4].

The efficient lighting system gives some benefits for example decrease in the emission of pollutants, optimum performance of the task, reliability, low maintenance and Low operating cost. It also consider two parameters:
(i) The user (optimal application of the equipment, lighting levels),
(ii) The applicable standards. These parameters lead the investigation through selection of the lamp, Type of the luminaire, level of illumination, Quantity and arrangement of equipment and Amount of electrical energy, expected consumption [8].
Led can generate more lumen per watt consumed, they can produce energy savings greater than 41% compared to the use of others bulbs [3], [4], [9].

1) Electrical Conductors Selection - Intensity Criteria:

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It is power transport capacity of electric conductors and it is calculated through of two equations according of the system.
Single phase systems

$$I = \frac{I}{V * f_p} \quad (1)$$

The factor which indicates the incidence of the temperature in the electrical conductor material is taken from the table II.

Temperature	Service Temperature	
	60°C	75°C
30 To 40	0,82	0,88
40 To 45	0,71	0,82
45 to 50	0,58	0,75
50 To 55	0,41	0,67
55 To 60	–	0,58
60 To 70	–	0,35

TABLE II: Correction Factor According to the Temperature.
Three phase systems

$$I = \frac{P}{\sqrt{3 * V * f_p}} \quad (2)$$

Where: P

Then, when the intensity is known the next data is taken
I= Phase Intensity (A).
P= Power (W). V= Voltage (V). f_p =Power Factor.

Them, the corrected intensity is calculated, taking into account the number of conductors per pipeline, the ambient and working temperature of the conductors whit the equation from the catalogues to define the electrical conductor section.

2) Electrical conductor selection- voltage drops criteria: In this criteria shall be used the equations according to the circuite characteristics.

Single phase systems

$$S = \frac{2 * \rho * P * I * f_p}{\Delta V} \quad (4)$$

Number three [10].

$$I_c = \frac{Il}{fN * fT} \quad (3)$$

Three phase systems $S = \frac{\sqrt{3} * \rho * P * I * f_p}{\Delta V}$ (5)

Where:

I_C =Allowed Corrected Intensity (A).
Il=Phase Intensity (A).
fN=Correction factor according to the electrical conductor numbers.
fT= Correction factor according to the temperature.

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The correction factor according to the electrical conductor numbers is taken from the table I.

Electrical conductor quantity	Factor
4 To 6	0,8
7 To 24	0,7
25 To 42	0,6
more than 42	0,5

TABLE I: Correction Factor According to the Electrical Conductor Numbers.

Where:

S= Electrical conductor seccion(mm).
ρ= Resistivity (Ω).
P= Power (W).
I= Phase Intensity (A).
f_p =Power Factor.
MV= Voltage (V).

Electrical conductor Material	Resistivity (Ω / mm2)
Soft Copper	0,01724
Semi-hard Copper	0,01783
Hard Copper	0,01790
Aluminium	0,0328

TABLE III: Electrical Conductor Resistivity

After know the necessary values shall be taken from the catalogues the values for the voltage variations according to EMELNORTE.The normalized M V are the following: (a) Lighting and sockets connections M V=1,5 %, (b) electric connection M V=5 % (c) electrical equipments M V=2,5 %.

Material	Y 20	Y 70	Y90
Copper	56	48	44
Aluminium	35	30	28
Temperature	20 °C	70°C	90°C

TABLE IV: Electrical Conductor Conductivity

The values of the conductivity and resistivity of the electrical conductors shall be taken from the III IV.

3) Sizing Power Transformer : To the projection of elec- trical systems it is necessary the adequate analysis of all the loads, coincidence factor, diversified demand, power factor, reserve power and the transformer power is obtained. In the table V the total loads for each one of the used parameters are shown [10], [11].

Load Summary		
Total Load	207,07	KW
Coincidence factor	0,8	0,82
Diversified demand	165,66	KW
Power factor	0,92	
Total demand	180,062	KVA
Reserve power	19,94	0,35
Selected Power Converter	200	KVA

TABLE V: Total Load

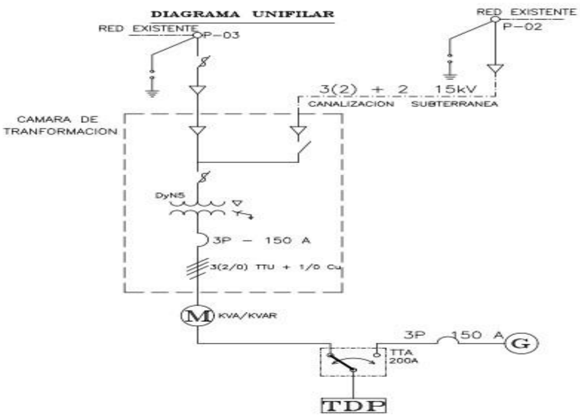

Fig. 5: Power Converter System

According to the table VII It is determined that the lighting system covers 13% of all installed load, analyzing the lighting load at 100% in one hour you can determine the value of the consumption in the lighting system is$ 2.52 in one hour.

Total Load	Unitary Value	Total Value
27,13 KW	0,093	$ 2,52

TABLE VII: Economical Value per Hour

The figure 5 shown the power converter installation system where is possible see the connection of the middle level In the table VIII and IX It can be seen that the monthly energy consumption is 6511.20KW, and the value to be paid for energy consumption is USD 605.54 with 3x17W fluorescent luminaires with 210 Lux with an average life of 20,000 hours given by the catalogs.

Installed Total Load	Total Value	Two working Shift (6Hours)	Working Days	Monthly Value
27,13 KW	$ 2,52	12	20	605,54

TABLE VIII: Economical Monthly Value.

voltage, derivation of the air electrical network to buried network connected to the primary section of the power converter and the secondary of it to the electrical control panels.

4) Economic Analysis: The (MES) has 532 Fluorescent Luminaires (3x17W), with 210 LUX, that is, each luminaire is composed of three tubes of 17 watts of power, 51W each luminaire.

Unitary Power	Luminaires	Utility Factor	Load	Diversified Demand
51W	532	0,5	27132	1356

TABLE VI: Diversified Demand Calculation

Fluorescent luminaire (3x17W) Monthly energy (KW)	Fluorescent luminaire (3x17W) monthly consumption (USD)
6511,20 20	605,54

TABLE IX: Economical Monthly Value

5) Economic Analysis Including LED lighting: In This part was considered the replacement of the 532 Fluorescent luminaires (3x17W) and 210 LUX, with 18W LED luminaires and 220 LUX. With a power of 18 watts for each luminaire. These data are shown in the table X

Unitary Power	Luminaires	Utility Factor	Load	Diversified Demand
18W	532	0,5	9576	4788

TABLE X: Diversified Demand Calculation

In the table XI using 18W LED luminaires with 220 LUX, the hourly consumption will be USD 0.89.

Total Load	Unitary Value	Total Value
9,58 KW	0,093	$ 0,89

TABLE XI: Economical Value per Hour

The monthly electricity consumption of 2299.20 KW, and the value to be canceled for energy service amounts to USD 213.83 with the 18W LED luminaire with 220LUX with an average life span of 60,000 hours given by the catalogs. These data are shown in the table XII and XIII.

Installed Total Load	Total Value	Two working Shift (6Hours)	Working Days	Monthly Value
9,58KW	$ 0,89	12	20	213,83

TABLE XII: Economical Monthly Value.

Fluorescent luminaire (3x17W) Monthly energy (KW)	Fluorescent luminaire (3x17W) monthly consumption (USD)
2299,20	213,83

TABLE XIII: Economical Monthly Value.

The savings money, only in energy consumption, monthly amount to USD 391.71 month by month, without the main- tenance savings due to tripling the life of the proposed Luminaires (LED 18W) like show the table XIV.

Luminaires (LED 18W)	Fluorescent luminaire (3x17W)	Monthly savings money
$ 213,83	$ 605,54	$ 391,71

TABLE XIV: The savings money

6) ECONOMIC FEASIBILITY ANALYSIS FOR THE REPLACEMENT OF LUMINAIRES.: It can be observed that, according to criteria of economic evaluation of projects, the implementation is feasible, because the VAN is positive and the TIR is greater than the discount rate; VAN 3428.85; TIR 16%; DISCOUNT RATE 12% .

Cash Flow						
Luminaire / labor savings	$7.660,00	usd/year				
Energy savings	$ 3.917,10	usd/year				
Investment luminaires / labor	$38.304,00					
Annual savings	**$ 11.577,10**	dolares/year				
Investment	**$ 38.304,00**					
tasa de descuento	12%					
Thrift	0	$11.577,10	$ 11.577,10	$ 11.577,10	$ 11.577,10	$ 11.577,10
Period Years	**0**	**1**	**2**	**3**	**4**	**5**
Investment	$-38.304,00					
net flow	-$38.304,00	$11.577,10	$11.577,10	$11.577,10	$11.577,10	$11.577,10
flujo neto descontad	-$38.304,00	$10.336,70	$9.229,19	$8.240,35	$7.357,46	$6.569,16
VAN	3428,85457					
TIR	16%					

. Fig: 6: ECONOMIC FEASIBILITY ANALYSIS III. RESULTS

Through criteria of economic evaluation of projects it is concluded that the implementation is feasible, due to the data obtained; VAN positive and TIR greater than the discount rates. With replacement of 3x32W, 210 LUX Fluorescent luminaires, with 18W LED luminaires, 220 LUX. In concordance with the calculation of the energy demand of the MES SUMAK YACHANA WASI, it was determined that the Lighting system covers 13% of the total installed load, so the study was focused on the lighting of the MES.

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