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Importance Of Savings In Electricity Consumption In Higher Education Institutions

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Abstract
This paper addresses the important need to implement measures for reducing electricity consumption in higher education institutions, focusing on technical, economic, and environmental benefits. The rationale behind these measures stems from the substantial advantages they offer in enhancing facility utilization, improving educational efficiency, and fostering environmental stewardship. With the context of the northwestern region of Mexico experiencing high summer temperatures, the study underscores the necessity of actions to mitigate electricity consumption, which translates into significant financial burdens for users.
A key proposal involves the replacement of inefficient lighting systems with modern, energy-efficient alternatives, particularly advocating for the adoption of Light Emitting Diode (LED) lighting technology. While seemingly straightforward, the widespread implementation of LED lighting remains largely unrealized in many educational buildings within the region. Employing technical-economic analyses facilitates determining necessary equipment investments, enabling insights into investment recovery periods, and anticipated annual savings on billing amounts.
Furthermore, the study emphasizes the environmental imperative, highlighting the role of reduced energy consumption in mitigating greenhouse gas emissions. By transitioning to LED lighting, there's a consequential reduction in power generation, notably decreasing emissions from fossil fuel-based power plants. This environmental benefit is significant in contributing to climate change mitigation efforts. Involving students from relevant disciplines in project implementation activities presents a dual opportunity to enhance their theoretical and practical training while instilling ecological consciousness. Leveraging legal and regulatory frameworks further enhances project viability, aligning actions with directives from governing bodies to optimize energy usage and minimize atmospheric pollutants.
Keywords: *LED lighting, energy savings, emissions reduction, efficient lighting.*

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I. Introduction.

Currently, there are multiple negative effects that impact the climate at a local and global level, with global warming, acid rain and the increase in suspended solid particles being some of the most representative (Anderson, Hawkins, & Jones, 2016); these effects are mainly caused by the exaggerated and poorly controlled burning of fossil fuels, which although it is true that they are necessary for the production and use of various forms of energy in human activities, it is also true that they are not the only usable energy sources (Naseri et al., 2019).

Global environmental impacts force prevention and remediation measures to be taken, as work must be done to slow or even reverse damage to multiple ecosystems. Countries and their institutions are becoming aware that the deterioration caused to the environment brings multiple problems to society, both in terms of health and economic, political and social (Noor, 2023). The great economic crises, the strongest and most changing natural phenomena, the scarcity of hydrocarbons and the great demographic explosion are examples that we experience every day.

Taking advantage of and efficiently using forms of energy in the different production processes forces institutions to implement different preventive or remedial actions.

At the United Nations Framework Convention on Climate Change in 2015, the Parties established the Paris Agreement, which recognized *"the need for a progressive and effective response to the pressing threat of climate change, based on the best available science."* It also "*recognizes that Parties may be affected not only by climate change, but also by the impacts of measures taken to address it"* (Matthäus & Mehling, 2020).

This is an indication that every day, more countries are becoming aware of all the consequences of the technologies applied to date to produce the energies that humanity requires and that serve to carry out daily activities. Apparently, today we are becoming aware of the damage caused to the planet by the use of fossil fuels as a means of energy production, although it should be remembered that there are others responsible for climate change (such as the dumping of industrial waste in bodies of water, the deforestation of large areas, the use of non-biodegradable materials, etc.) and that, together with the burning of hydrocarbons, represent the greatest threat to the sustainability of the planet.

In the same document (*Paris Agreement),* the need to educate, train, sensitize and make all levels of the population responsible for the consequences of irresponsible actions that contribute to climate impact in all regions is made clear, as well as to participate in the actions applied to reduce the impact of the damage and the results obtained from these actions (Ohara, 2022). That is, not only to apply measures with the aim of reducing the damage to the planet, but also to inform countries about what measures have been implemented and the results that are being achieved. It is a matter of looking at this situation in a global way, understanding that isolated actions will not lead to conclusive results to reverse the current situation.

A few years ago, Mexico began to implement public policies aimed at reducing the contributions to climate change (Buira et al., 2021). It is recognized that the sustainable use of energy is one of the fundamental components that will help build a prosperous country, as it contributes to the preservation and rational use of non-renewable resources, increases the productivity of companies, reduces the effects of climate change, and improves the living conditions of Mexicans. Within the regulatory framework, in 2008 the Law for the Sustainable Use of Energy was established, and, within it, the National Commission for the Efficient Use of Energy was created under the Ministry of Energy. In 2013, both bodies were instructed to include in the National Program for the Sustainable Use of Energy (PRONASE) "a transition strategy to promote the use of cleaner technologies and fuels."

It is worth mentioning that in previous years, the implementation of actions in the field of energy began, which were Mexico's first steps towards mitigating damage and effects on the environment. Savings policies are established in various government sectors, mainly in the sectors of energy production and hydrocarbon exploitation, it begins with the application of regulations in terms of technical specifications applicable to equipment, appliances and systems marketed in the country, in order to limit their consumption of electrical and thermal energy, in the residential, commercial, services, industrial, transport and agricultural (Official Mexican Energy Efficiency Standards) (NOM).

The Daylight Saving Time Program (Law of the Time System in the United Mexican States, D.O.F. December 29, 2001 and the Decree establishing the Seasonal Schedule in 2002) is implemented as a measure focused on reducing energy consumption through the differential of schedules in activities and taking advantage of natural light. Various results are achieved with this measure. It should be clarified that the Daylight Saving Time Program ceases to apply in the country in 2022, with the entry into force and publication in the Official Gazette of the Federation of the Law of Time Zones in the United Mexican States. In 1999, the Federal Public Administration established its Energy Efficiency Program to promote the sustainable use of energy and establish a process of continuous improvement to promote energy efficiency in buildings, vehicle fleets and facilities of federal government agencies and entities, through actions of good practices and technological innovation that contribute to the efficient use of public resources and sustainability.

Within the framework of PRONASE, one of its objectives stands out, which seeks to strengthen energy efficiency governance systems and instances at the federal, state and municipal levels and integrating public, private, academic and social institutions.

The application of Energy Audits represents an effective tool to determine the ways in which different types of energy are used in any field (Thollander, Karlsson, Rohdin, Wollin, & Rosenqvist, 2020). Knowing how institutions contract their energy, how they consume it in their processes, how much it affects their costs, their relative position with respect to other similar institutions and the possible improvements to reduce their energy costs, are the origin of these. Energy Audits establish procedures for the verification of consumption that is mainly carried out in the industrial field, however, this methodology is feasible to apply in any type of installation where some form of energy is used.

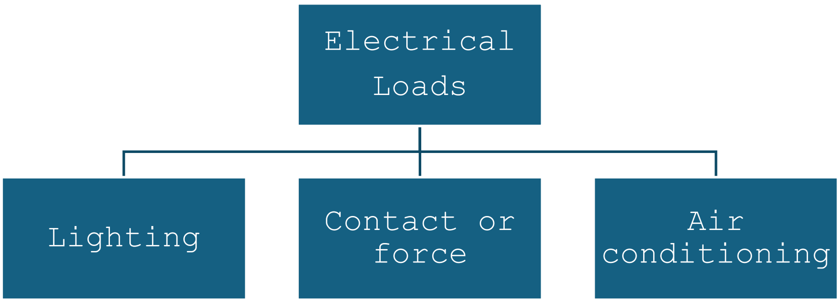
Any new and sustainable project will seek to comply with the government policy presented in PRONASE, reducing energy consumption in public buildings, applying modern and efficient technology, supported by new knowledge, and reducing the emission of agents that cause climate change.

Statement Of The Problem.

In northwestern regions of the country, weather conditions during the summer months can be extreme in some cases (Hernandez-Ochoa et al., 2018). Electricity consumption is increased in order to reduce environmental effects due to high temperatures, which increases the energy expenditure of equipment, reduces its useful life due to thermal effects, increases electricity billing costs and, in the case of educational institutions, decreases comfort in students, teachers and support staff, causing a decrease in academic achievement.

In higher education institutions, spaces for classrooms, workshops, libraries, service offices, administrative spaces, etc., represent electrical loads divided into three large groups according to their use: lighting loads, contact or force loads, and air conditioning loads.

Figure 1 Groups for electrical loads classification.



$$P_t = \sum P_{lighting} + P_{force} + P_{ac}$$

Where:

P_t indicates the total installed load.

$P_{lighting}$ is the sum total of the lighting systems used in the institution.

P_{force} indicates the total power available at force contacts.

P_{ac} represents the installed power of air conditioning systems.

Among the three types of loads mentioned, the one that represents the highest consumption is that of air conditioning equipment (air conditioners). It certainly appears as an important element within the components that make up electricity billing.

The contact load, according to the regulations, could be considered as a non-continuous charge, since its use is not permanent, but rather intermittent, for short periods of time. Even for the calculations of the elements of the installation, the contact load is affected by "demand factors".

In the case of lighting, it represents a significant amount if we talk about installed load. The use of lighting is almost permanent in educational institutions (such as, for example, continuous class schedules from early in the morning until sometimes late at night).

Lighting systems in educational institutions must comply with certain illuminance values in volt-ampere per square meter (VA/m2) that are established by standards, which are basically determined according to the space to be illuminated and the activity to be carried out (Krarti, 2018). Due to the type of activity to be carried out, the regulations contemplate that, for the purposes of load calculations, the lighting of an educational institution is computed at 100%. As a result of the continuous use of lighting systems, the lack of periodic maintenance of lighting equipment (luminaires and lamps), in addition to the use of obsolete light emission technologies, there is high electricity consumption, which increases because of thermal dissipation in the summer months, causing a high turnover for consumers.

The problem with the current configuration is economic-environmental, and given that government policies are pushing for austerity measures, it is necessary to reduce electricity consumption and consequently GHG emissions (de Souza, da Silva, Fontenele, Barbosa, & de Oliveira Jesus, 2019).

Table 1 General lighting loads by type of property. Taken from NOM-001-SEDE-2012-Electrical installations (Use).

Table 220.12 General Lighting Loads by Occupancy

Type of Occupancy	Unit Load: Volt-Amperes/ Square Meter	Unit Load: Volt-Amperes/ Square Foot
Armories and auditoriums	11	1
Banks	39[b]	3½[b]
Barber shops and beauty parlors	33	3
Churches	11	1
Clubs	22	2
Court rooms	22	2
Dwelling units[a]	33	3
Garages — commercial (storage)	6	½
Hospitals	22	2
Hotels and motels, including apartment houses without provision for cooking by tenants[a]	22	2
Industrial commercial (loft) buildings	22	2
Lodge rooms	17	1½
Office buildings	39[b]	3½[b]
Restaurants	22	2
Schools	33	3
Stores	33	3
Warehouses (storage)	3	¼
In any of the preceding occupancies except one-family dwellings and individual dwelling units of two-family and multifamily dwellings:		

For the above reasons, it is important to carry out this type of study on current lighting systems, which are considered not to offer the required operating conditions.

Variables such as power, luminous flux, voltage and frequency of supply, design life, influence the final impact of the project; these and other aspects must be considered during the determination of the lighting equipment to be selected (Ryckaert, Smet, Roelandts, Van Gils, & Hanselaer, 2012). As you can see, there are many options in the market to select the most appropriate one for the needs and characteristics of the project in question. From an economic point of view, the important and rapid development of these light emitting systems offers multiple economic advantages, as there are many options in terms of unit cost of each piece of equipment.

Table 2 presents a comparison of the main technical specifications of different T8 lamps, offered by some manufacturers.

Table 2 Technical Characteristics T8 LED Lamps 18 watts 1200 mm

Product & Manufacturer	Electrical Specifications	Luminic Flow (nominal)	Life
LED T8 18 w.	*Input frequency 50-60 Hz. Vaultage (nom.) 100-240 V. Nominal power 18 W*	1850 lm	30,000 h
LED T8 18w.	*Input frequency 50-60 Hz. Vaultage (nom.) 100-240 V. Nominal power 18 W*	1400 lm	20,000 h
LED T8 16w.	*Input frequency 50-60 Hz. Vaultage (nom.) 100-240 V. Nominal power 16 W*	1600 lm	15,000 h
LED T8 15 w.	*Input frequency 50-60 Hz. Vaultage (nom.) 120-277 V. Nominal power 15 W*	2150 lm	50,000 h

Source: Self elaboration based on Technical Sheets of Manufacturers.

Within the proposals and due to the technical characteristics, it is feasible to consider that if projects of this type are approved for application and once the necessary equipment is acquired, the installation of these will be carried out by students, advised by professors. This would help students develop practical knowledge about modern and efficient facilities. Another goal that would be achieved would be to raise awareness about the development of high-efficiency projects, completely friendly to the environment, which would serve as a seed for the realization of other projects of this type, both in the field of the school and in the development of professional projects in the work performance of the students.

Carrying out pilot tests with the proposed lighting systems, determining the lighting values in order to compare them with standardized values, determining consumption tests with power quality analysis equipment, electrical measurements and tests to determine the influence of the lighting temperature on the air conditioning systems, they will serve to make a more solid support for the benefits of this type of project.

As a result, it seeks to make innovative, sustainable, and environmentally friendly proposals, so that, when adopted by the institution, they provide the means to obtain a real reduction in the consumption of electricity, the reduction of expenses for billing such energy and mainly the reduction of damage to the environment.

In summary, these projects have the following quantifiable impacts on the performance of the daily activities of the institutes:

Electricity consumption is considerably reduced.

According to the purposed model, and considering constant thermal loads, effect of reducing energy consumption for lighting systems will have an additional effect on air conditioning systems demand, so considering that a rate between the uses of lighting to air conditioning systems can be estimated, energy reduction could be evaluated as:

$$\Delta E = \Delta E_l + \frac{\xi \Delta E_l}{\eta_{ac}}$$

Where:

□E_L Change in lighting energy	kWh	
□$_{ac}$ Air conditioning efficiency	%	
□ Rate of AC/Lighting usage		h/h
□E Change in energy		kWh

They help reduce the effects on climate change currently affecting the planet:

Since carbon dioxide emissions, for the effects of this project, are function of the electricity consumption (E), the combined efficiency of production, transmission and distribution (□) and the technology used to produce it (□).

$$CO_2 = F(E, \nu, \theta)$$

For example, considering a natural gas fired power plant, the direct emissions could be approximated by:

$$CO_2 = \frac{3.6\,E}{\eta * LHV} * \frac{44}{16}$$

Where:

E Consumed energy		kWh
□ Combined efficiency	%	
LHV Low heating value of fuel	MJ/kg	
CO_2 Emissions of CO_2	kg	

Therefore, an energy consumption reduction would result in the corresponding emissions reduction:

$$RCO_2 = \frac{3.6\,\Delta E}{\eta * LHV} * \frac{44}{16} = CO_2(1 - \alpha)$$

Where:

DE Change in energy consumption		kWh
□ Reduction fraction		%
RCO_2□ Reduction in emissions	%	

Economic savings due to billing reduction as well as due to the longer useful life are also predicted for the replacement of conventional lamps by LED technology T8 lamps.

The governing bodies of the operation of the educational institutions establish actions to efficiently use the Institutes own resources and suggest measures to reduce expenditure in different areas. The following actions are highlighted, applicable to this study: improvement of electrical installations, replacement of obsolete and inefficient equipment, change of lighting for energy-saving systems, programs for the proper use of the systems, among others.

Recently, an initiative has been launched that contemplates the efficient use of electrical energy, creating a culture of optimization of resources, awareness, and values. It is a savings program that involves all the areas dependent on the central body, which includes several stages of energy audits and whose objective is to reduce payments for electricity billing in the centers and campuses. Formally, programs of activities and actions are presented that demonstrate the commitment to energy efficiency to reduce energy consumption.

II. Conclusions

Adequate lighting is a guarantee of health, efficiency in the study and learning of children and adolescents, as well as in the reduction of visual fatigue. The lighting installations of educational facilities must be equipped with systems that provide a comfortable and sufficient visual environment, in accordance with the varied tasks and activities that are carried out during the teaching period. Good lighting provides a pleasant and stimulating environment for students and teachers, that is, visual comfort that allows them to follow their activity without demanding from them an extra visual effort, caused by inadequate lighting.

Developing this type of project allows us to obtain information on how electrical energy is consumed in lighting, in specific areas of educational institutions. Making proposals for a better use, which represent savings in the electricity bill, is the objective that is intended to be achieved.

Economic savings in the operation of educational institutions are of vital importance since the resources available are often limited and insufficient for the simple performance of essential activities.

Each economic measure implemented represents a resource that can be used in other actions to develop and strengthen their educational work. These are resources that will be able to support other programs that will enhance their growth, increase their infrastructure and equipment, while training their students in energy saving aspects.

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References

[1]. Anderson, T. R., Hawkins, E., & Jones, P. D. (2016). Co2, The Greenhouse Effect And Global Warming: From The Pioneering Work Of Arrhenius And Callendar To Today's Earth System Models. Endeavour, 40(3), 178–187. Https://Doi.Org/10.1016/J.Endeavour.2016.07.002

[2]. Buira, D., Tovilla, J., Farbes, J., Jones, R., Haley, B., & Gastelum, D. (2021). A Whole-Economy Deep Decarbonization Pathway For Mexico. Energy Strategy Reviews, 33, 100578. Https://Doi.Org/10.1016/J.Esr.2020.100578

[3]. De Souza, D. F., Da Silva, P. P. F., Fontenele, L. F. A., Barbosa, G. D., & De Oliveira Jesus, M. (2019). Efficiency, Quality, And Environmental Impacts: A Comparative Study Of Residential Artificial Lighting. Energy Reports, 5, 409–424. Https://Doi.Org/10.1016/J.Egyr.2019.03.009

[4]. Hernandez-Ochoa, I. M., Asseng, S., Kassie, B. T., Xiong, W., Robertson, R., Luz Pequeno, D. N., … Hoogenboom, G. (2018). Climate Change Impact On Mexico Wheat Production. Agricultural And Forest Meteorology, 263, 373–387. Https://Doi.Org/10.1016/J.Agrformet.2018.09.008

[5]. Krarti, M. (2018). Advanced Building Energy Efficiency Systems. Optimal Design And Retrofit Of Energy Efficient Buildings, Communities, And Urban Centers, 45–115. Https://Doi.Org/10.1016/B978-0-12-849869-9.00002-8

[6]. Matthäus, D., & Mehling, M. (2020). De-Risking Renewable Energy Investments In Developing Countries: A Multilateral Guarantee Mechanism. Joule, 4(12), 2627–2645. Https://Doi.Org/10.1016/J.Joule.2020.10.011

[7]. Naseri, N., El Hani, S., Aghmadi, A., Mediouni, H., Aboudrar, I., & Benbouzid, M. (2019). Solar Photovoltaic Energy Storage As Hydrogen Via Pem Fuel Cell For Later Conversion Back To Electricity. Iecon Proceedings (Industrial Electronics Conference), 2019–October, 4549–4554. Https://Doi.Org/10.1109/Iecon.2019.8927094

[8]. Noor, A. (2023). Climate Change Adaptation And Mitigation In Cities. Urban Climate Adaptation And Mitigation, 23–47. Https://Doi.Org/10.1016/B978-0-323-85552-5.00001-4

[9]. Ohara, K. (2022). Mitigation. Climate Change In The Anthropocene, 123–143. Https://Doi.Org/10.1016/B978-0-12-820308-8.00003-9

[10]. Ryckaert, W. R., Smet, K. A. G., Roelandts, I. A. A., Van Gils, M., & Hanselaer, P. (2012). Linear Led Tubes Versus Fluorescent Lamps: An Evaluation. Energy And Buildings, 49, 429–436. Https://Doi.Org/10.1016/J.Enbuild.2012.02.042

[11]. Thollander, P., Karlsson, M., Rohdin, P., Wollin, J., & Rosenqvist, J. (2020). Energy Auditing. Introduction To Industrial Energy Efficiency, 61–87. Https://Doi.Org/10.1016/B978-0-12-817247-6.00005-5