Journal of Engineering and Technology for Industrial Applications

ISSN ONLINE: 2447-0228

ITEGAM-JETIA

Manaus, v.11 n.53, p. 90-97. May/June., 2025.
DOI: https://doi.org/10.5935/jetia. v11i53.1577

RESEARCH ARTICLE OPEN ACCESS

ENERGY IMPACT OF LIGHTING SYSTEM REPLACEMENT IN A PUBLIC EDUCATION INSTITUTION

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ARTICLE INFO

Article History
Received: January 21, 2025
Revised: February 20, 2025
Accepted: May 15, 2025
Published: May 31, 2025

Keywords:
Energy efficiency,
Energy consumption,
Environmental impact,
Lighting,
LED technology.

ABSTRACT

Lighting loads represent a significant percentage of global energy consumption, becoming an important issue to analyze in order to contribute to a more efficient use of electrical energy. This work presents an analysis of the lighting energy demand in the buildings of the College of Engineering - UNCPBA along with a proposal for improvement using LED technology. A survey of each of the buildings and spaces has been carried out to identify the current lighting conditions of the different College work areas and the associated energy consumption. The analysis includes the impact in terms of energy and lighting quality, replacement costs and return on investment. The calculation of greenhouse gases (GHG) and their environmental impact is also presented. The results of the study indicate that the transition to LED lighting would result in approximately 60% savings in electrical energy consumption at the College. The study draws conclusions regarding the efficiency of the lighting process and the reduction of environmental impact.

I. INTRODUCTION

The global trend towards a more efficient use of natural resources leads to the analysis and restructuring of energy-consuming systems. The world's population growth entails a marked increase in electricity consumption in all areas of demand since electricity has greatly improved the population's quality of life. However, on multiple occasions, excessive energy consumption, improper energy use and electrical installations / electrical machines working in poor conditions are situations that directly or indirectly involve Energy Efficiency (EE) [1]. On the one hand, EE involves making a series of changes and/or improvements in different consumption sectors to reduce the energy used for certain services or activities [2],[3]. On the other hand, EE is closely aligned with the necessary investments and policies to make the changes that lead to improvements in energy-consuming systems [4],[5].

The energy demand has grown due to various factors [6]. In addition, electrical energy has a higher relative cost compared with other energies [7]. Therefore, focusing on increasing the EE of electrical systems is a relevant issue as one of the ways to face the situation. In particular, lighting loads represent an important percentage of the electrical energy consumption in different areas [8],[9], and represent approximately up to 20% of the global energy consumption [10],[11]. Therefore, analyzing the problem of energy demand due to lighting loads becomes a matter of great importance in the context of EE. Light Emitting Diodes (LED) lights have higher efficiency compared to other technologies such as incandescent bulbs, halogen lamps, and Compact Fluorescent Lights (CFL). In comparative terms, the required energy to supply a given luminous flux is lower in the case of using lighting through LED technology [9],[12],[13]. Moreover, LED lamps have a duration 5 times longer than CFL lamps and their electrical consumption is around 50% lower [14].

LED lamps also limit the flickering effect produced in fluorescent lamps with conventional ballast, constituting another positive aspect [15]. This phenomenon can produce headaches and visual and neurological effects on humans [16], affecting their health and work environments. So, it should be considered among the factors that determine the decision to move to LED lighting. However, unlike fluorescent lamps, LED lamps are powered by DC current, from a rectification process. Two wave characteristics influence the flickering. These are the ripple voltage and the frequency at which the ripple occurs [17]. This can lead to intermittency or oscillations in light intensity, which also affect the human eye. According to [18] have analyzed and quantified the flickering effect in commercial LED lights. According to the study, percentage differences can be found between commercially known brand lamps and low-cost generic lamps. However, the flickering effect is considered to be almost completely reduced in LED lamps. To mitigate these effects, international organizations such as the IEEE makes recommendations on maximum flicker levels to avoid harmful effects on human health [19]. Furthermore, the lifespan of LED light sources is not affected by the switching frequency. In general, unlike fluorescent lamps that emit light in all directions, LED light sources radiate in one direction (depending on the position of the lamp); therefore, their optical efficiency is better. Thus, LED lights have better electrical characteristics and, in addition, a positive environmental impact compared with fluorescent ones [20].

In particular, activities that are developed in different areas, such as residential, educational, administrative, industrial, among others, require a certain light level on the work plane.

Several authors have presented studies to characterize the work areas, identifying the conditions in which the activities are developed. These studies allow taking action to improve the results in relation to EE and to verify the illumination levels according to regulations and standards. For example, there are studies aimed at saving energy by replacing of conventional lamps with LED technology in commercial areas and public buildings [21-23]. Others focused on the techno-economic considerations derived from the replacement in offices building [24], and methodologies to verify the illumination levels in offices, classrooms, laboratories and other spaces in educational institutions to consider permissible values [24-27]. Other studies are aimed at safeguarding the safety and health of workers in industrial installations [28], or to evaluate the use of LED lamps in residential environments [29], among others.

This work presents a case study in the buildings of the College of Engineering – UNCPBA, including the analysis of lighting energy demand and an improvement proposal using LED lamps. The analysis comprises the impact of energy and lighting quality, replacement cost and return on investment, the calculation of greenhouse gas (GHG) emissions and its environmental impact.

The paper is organized as follows. The materials and methods section describes the situation before the replacement of the fluorescent tubes with LED technology, together with the energy savings achieved, considering the same buildings. Subsequently, the method used to measure the light levels is described. The results section presents the results obtained, an analysis of the economic issues and the environmental impact. This is followed by a discussion of the results and contributions to the sustainable development goals promoted by the United Nations. Finally, the conclusions of the work are presented.

II. MATERIALS AND METHODS

The indoor lighting system in the building facilities at the College of Engineering - UNCPBA, has been characterized by the use of fluorescent tubes. The system has a non-optimized distribution. This means that the proper illumination levels recommended by Federal Law no. 19587 on occupational health and safety cannot be properly achieved [30]. In view of this situation, the goal is to introduce improvements in the efficiency/energy savings variables, to achieve comfortable lighting for users, and to estimate the necessary investment to restructure the lighting system. In order to identify the current indoor lighting conditions of the different sectors and the associated energy consumption, a survey of each of the College's buildings and areas was conducted. Table 1 summarizes the current situation based on this survey. It is observed that the equipment used are all 36 W fluorescent tubes. If losses in electronic ballasts, reactances, and auxiliary ignition devices are considered, the total consumption per element is 40 W.

II.1 MOVING TOWARDS LED TECHNOLOGY

This subsection shows, through a calculation example, the energy savings achieved by using LED tubes instead of traditional fluorescent tubes. It is proposed to replace the existing devices with LED tubes of 16W, considering similar light level conditions and geometrical disposition of the previous one. This replacement means that with 40 % of the energy of traditional fluorescent tubes, it is possible to obtain the same performance with LED tubes. With this new electrical power reference value, the total power installed on each building is calculated once again. Table 2 shows the electrical power with LED technology and the potential power savings.

The analysis carried out in the main buildings of the College, shows that the installed capacity is reduced by 60%, as expected. This means that 13968W of electrical power can be saved. Figure 1 shows the representation of the current installed power and the potential savings incorporating LED technology.

II.2 ELECTRICAL ENERGY SAVINGS

From the analysis carried out in the previous subsections, it is possible to quantify the electrical energy saved on a daily, monthly and annual basis as a result of replacing traditional fluorescent tubes with LED tubes. For this purpose, an estimation of the average hours of daily usage is utilized, considering that the activities begin at 8:00 a.m. and end at 8:00 p.m. during weekdays. It should be clarified that this time distribution does not apply to all sectors. There are some sectors where the lighting is on for less time, others where it is on for longer, and sectors where it is on 24 hours a day, even on weekends or non-working days.

Table 1: Installed power in the College buildings.

Building	Number of lamps	Installed power (W)
Main Building	241	9640
Students' Center	4	160
Civil Engineering	84	3360
Electromechanical Engineering	62	2480
Industrial Engineering	52	2080
Chemical Engineering	118	4720
Laboratory of Microparticles	21	840
Total	582	23280

Source: Authors, (2025).

Based on the above, an estimate of 12 hours of daily use is appropriate. Table 3 presents the electrical energy savings obtained, considering the lights on 12 hours a day on average, during 5 days a week.

In most of the Argentinean territory, a reference value for electricity consumption of 150 kWh per month has been established, which corresponds to the social tariff and from which the reference prices for electricity are determined by the Ministry of Energy and Mining – Argentina [31],[32]. Therefore, if the aforementioned value is taken as a reference, it can be deduced that the monthly electrical energy savings would be equivalent to the approximate consumption of 22 households with social tariffs, just by replacing the existing lighting system in the College with LED technology. However, the average electrical energy consumption is considered to be higher than this threshold value. According to Larrere [33] the most frequent consumption is around 150 kWh per month and the average consumption would be around 230 kWh per month taking into account the residential demand in Argentina. Considering this last value as the average monthly consumption of a household, the savings would be equivalent to the monthly consumption of 15 households, which clearly indicates the importance of replacing the lighting system in the College buildings.

Table 2: Electrical power in the College buildings using LED technology and electrical power savings.

Building	Electrical power with LED light (W)	Electrical power savings (W)
Main Building	3856	5784
Students' Center	64	96
Civil Engineering	1344	2016
Electromechanical Engineering	992	1488
Industrial Engineering	832	1248
Chemical Engineering	1888	2832
Laboratory of Microparticles	336	504
Total	9312	13968

Source: Authors, (2025).

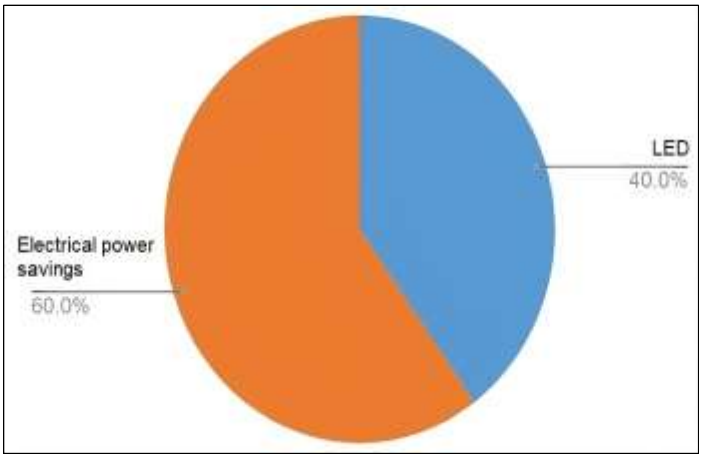

Figure 1: Representation of current installed electrical power vs. potential savings by using LED technology.
Source: Authors, (2025).

Table 3: Electrical energy savings in the College buildings using LED tubes.

Electrical power savings (W)	Daily energy savings - 12 h (kWh)	Weekly energy savings - 5 days (kWh)	Monthly energy savings - 20 days (kWh)
13968	167.6	838.1	3352.3

Source: Authors, (2025).

II.3 LIGHT LEVEL MEASUREMENTS – PREMISES AND GUIDELINES

Lighting conditions achieved with LED lights must be measured through a standardized method to meet the requirements of federal rules on occupational health and safety, and occupational hazards.

Various manufacturers of lighting equipment provide the photometric data for their products. Based on this data, it is possible to evaluate the luminous flux reaching the working plane. There are two alternatives for this: a) analysis through simulation, and b) by experimental tests. Simulation is useful when the lighting device is not available or when different alternatives need to be evaluated.

In this work, the verification of the lighting conditions was carried out experimentally through different tests. According to the manufacturer's specification, a lighting system based on fluorescent tubes has a lower luminous flux utilization when compared to LED tubes, so this is a premise for this work.

This situation is illustrated in Figure 2. In Figure 2(a), corresponding to a fluorescent tube, the luminous flux is emitted in all directions, and must be reflected by the surface of the luminaire to direct it towards the work plane. Figure 2(b) depicts a tube with LED technology. In this case, the luminous flux is mostly emitted directly to the work plane due to its constructive shape.

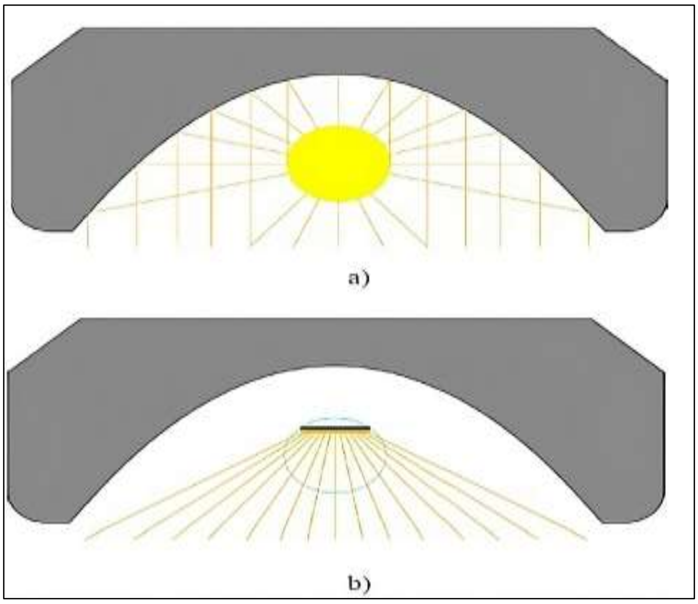

Figure 2. Luminous flux utilization, a) fluorescent lamps, and b) LED tubes.
Source: Authors, (2025).

II.4 MEASUREMENT METHOD

To properly characterize a certain sector, it is necessary to measure the luminous flux per unit area, that is, the light level or illuminance, in lx. In other words, the luminous flux that reaches the work plane. To exemplify the applied method, the case of light level measurements in a typical office commonly used by professors is presented.

The method is divided into two stages to measure, 1) illuminance on the work plane to obtain a first approximation and choose the more convenient luxmeter scale, and subsequently, 2) illuminance using a measurement point grid covering all the analyzed zone, according to the illumination measurement protocol in work environments that is part of the Resolution SRT no. 84/2012 of the Occupational Hazards Superintendence – Argentina [34]. This protocol is mandatory to measure the light level according to the foresight of the Federal Law no. 19587 on Hygiene and Safety at Work – Argentina [30].

An analog portable luxmeter model 3281 from Yokogawa Electric Corporation, available in our electrical and electronics laboratory, was used to perform the measurements on the work plane. This instrument contains a selenium cell sensor with a plastic covering, connected to a passive instrument built on a linear scale with a measuring range of 0 to 3000 lx divided into three ranges, and an accuracy of ± 7% of reading (23°C ± 2°C).

As part of the first stage, the measurement was made on the work plane considering a conventional fluorescent tube of 36 W. Subsequently, the same measurement procedure was carried out, but replacing the fluorescent tube with a 16 W LED technology tube. Both measurements were made without the presence of natural light.

Both values were below 200 lx, so the 300 lx scale was used to perform the measurement. As expected, once the measurement was made, it was found that the illuminance using LED technology was higher than that reached by the fluorescent tube. The obtained measurements with both technologies are presented in Figure 3.

For fluorescent tube lighting, the illuminance was 150 lx (Figure 3 a)), while with LED tube, 170 lx was reached (Figure 3 b)). Considering the luxmeter specification, the measurement error is ± 10.5 lx in the first case and ± 11.9 lx in the second case, respectively.

As part of the second stage, a point grid covering all the analyzed zone was used to obtain the average illuminance. The method is based on the division of the considered area into several equal areas, each of them ideally square. Figure 4 shows the grid and their dimensions, corresponding to a typical office taken as an example. Thus, the illuminance at the center of each subarea is measured at the altitude of 0.8 m over the floor level (work plane) to calculate the average illuminance (I_{L0}).

The precision in average light level measurement is influenced by the number of points being used. Equation (1) was used to determine the minimum number of measurement points (N_{mp}) as a function of the location index (L_i) [34]:

$$N_{mp} = (L_i + 2)^2 \quad (1)$$

The location index (L_i) was determined through Equation (2) where l and w are the length and the width of the considered area, respectively, and Mh is the mounting height, that is, the vertical distance between the center of light source and the work plane.

$$L_i = \frac{l \times w}{Mh \times (l + w)} \quad (2)$$

The value of the location index is rounded to the upper integer number, except for values equal to or greater than 3, in which case 4 is taken. The measurement method is complemented with a table for each of the college buildings.

Figure 3: Comparison of the light level on the work plane, a) fluorescent tube, and b) LED tube.
Source: Authors, (2025).

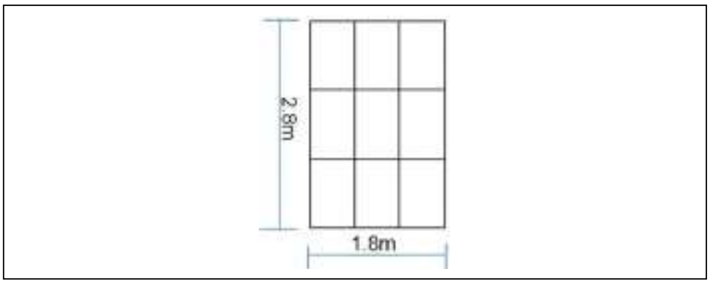

Figure 4: Grid used for measuring average illuminance.
Source: Authors, (2025).

III. RESULTS AND DISCUSSIONS

When calculating the average value resulting from the 9 measurements for both cases, an average illuminance value (I_{L0}) of 145 lx with fluorescent tube and 165 lx with LED tube were obtained, respectively.

It should be highlighted that due offices' dimensions, and the arrangement and length of the luminaire that contains the tube, the measured values were all very close to the average value in both cases, resulting in a high level of uniformity. Table 4 summarizes the measured values obtained for the analyzed case.

III.1 ECONOMIC ISSUES

The return-on-investment time and potential economic advantages of the proposal were estimated using the Simple Payback Time (SPBT) indicator [35]. This estimation has been carried considering the electrical energy consumption analysis made in materials and methods section, the costs associated with the replacement of existing lights with LED technology, and the electrical energy consumed (cost provided by local energy distributor). The bonus per kWh was taken into account to estimate the composition of the electrical energy cost, and all those costs related to provincial and municipal taxes directly impacting the final expense paid by the user.

Table 5 presents the calculation of the electrical energy savings achieved by using LED tubes instead of fluorescent ones. The recorded values take into account the total values of annual energy demand in terms of lighting in the College of Engineering per year, with both types of technologies.

Currently, the acquisition costs of both types of tubes are comparable. This is due to the important development and massive commercialization of LED technology, which allowed the reduction of its cost. However, for its replacement, all labor costs must be taken into account for the adaptation of existing systems. In this case, an adaptation cost equal to the cost of the LED tube was considered, so the new lighting system requires an investment of twice the acquisition value of the tube, for each tube.

With the aforementioned considerations, the calculation of the return-on-investment time was carried out without considering the annual interest rate, that is, accumulating the energy savings per year to cover the additional value of the investment. Equation (3) used for the calculation of the indicator, corresponds to the static method SPBT [35].

$$SPBT = \frac{i_i}{A_{es}} \qquad (3)$$

Where SPBT is the Simple Payback Time in [years], i_i is the additional investment corresponding mainly to the adaptation cost of the installation in [U$S], and A_{es} is the annual energy savings due to the lighting system replacement in [U$S].

Table 4: Illuminance in an office using the measurement point grid method.

Variable	Value
L	2.8 m
W	1.8 m
Mh	1.7 m
L_i	0.64 (rounded to 1)
N_{mp}	9
I_{L0} with fluorescent tube	145 lx
I_{L0} with LED tube	165 lx
L	2.8 m

Source: Authors, (2025).

To obtain the SPBT, two possible scenarios were proposed. The first one (scenario I), corresponds to the current lighting system appropriately working. Therefore, the investment to be made corresponds to the LED tube cost plus the adaptation cost. In the second one (scenario II), the criterion adopted was that the existing tube had reached the end of its lifetime. Therefore, regardless of the technology to be used, the cost of the lamp must be considered within the building maintenance cost. Under this condition only the adaptation cost of the installation was considered. This means that the cost associated with scenario II is equivalent to half that of scenario I.

In Table 6, the obtained SPBT are presented for the two proposed scenarios. As can be seen from Table 6, for the most unfavorable condition, the time needed to recover the additional investment is less than one year, making the replacement proposal economically viable. Alternatively, if the total investment is not available, a gradual replacement plan can be carried out.

III.2 ENVIRONMENTAL IMPACT

The energy savings as a result of technology replacement directly contributes to the optimization of natural resources, since most of the energy matrix in Argentina is composed of natural gas. In this Section, the reduction in the volume of greenhouse gases, product of the decrease in electrical energy consumption, was exclusively analyzed.

In order to estimate the volume of CO_2 production, the emission factors corresponding to the Argentine grid of electrical energy, provided by the Secretariat of Energy were taken into account [36]. These factors consider the amount of CO_2 emissions resulting from the production of a unit of electrical energy from the Argentine grid. The data of the last report accessible on the platform correspond to the year 2023.

Table 5: Annual electrical energy demand and savings in the College buildings.

Energy demand – fluorescent tubes (kWh)	Energy demand – LED tubes (kWh)	Energy savings (kWh)
67046.4	26818.6	40227.8

Source: Authors, (2025).

Table 6: SBPT obtained for the proposed scenarios.

Scenario	i_i (U$S)	SPBT (years)	SPBT (months)
1	1315.8	0.96	11.6
2	657.9	0.48	5.8

Source: Authors, (2025).

Figure 5 presents data from the report, considering the 2007-2023 period. Until 2019, a decrease in emission factors is observed as a result of the advance of renewables in the energy matrix in recent years. However, in 2020 and 2021, the emission factor shows an increasing trend, which is reversed from 2023 onwards. The value of the emission factor in 2023 is similar to that of 2019, and considering the behavior of the curve and the previous trends, as well as the actions taken in recent years regarding energy generation, electric mobility, and others, the emission factor could decrease again.

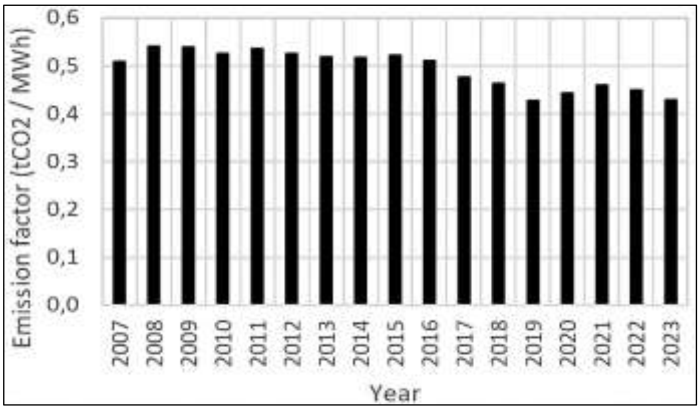

Figure 5: Emission factor during 2007-2023 – Argentine grid of electrical energy.
Source: [36].

It should be pointed out that the factors are closely related to the operating margin and construction of power plants. Depending on the technology of each of them, a weighting is made to obtain a combined margin emission factor.

Thus, the emission factor corresponding to the operating margin of the year 2023, whose value is 0.429 tCO_2/MWh, was used for the analysis. Considering the annual energy saved, affected by the emission factor, a value of 17.2 tCO_2 was obtained for this case study.

The effect of greenhouse gas reduction on climate change is significant. This becomes even more important if its projection to other local or national buildings and institutions is considered.

The 60 % energy consumption reduction in lighting is a unique opportunity, enabled by more efficient lighting technologies.

In addition, it should be noted that fluorescent tubes, at the end of their lifetime, are transformed into hazardous waste. This is due to the presence mainly of mercury mixed with argon in the vapor state, which can cause serious environmental and human health problems when broken [37-39]. When a mercury leakage occurs, it can remain in the atmosphere for a long time before being deposited on the surface, and can be transported to places far from the emission source [40].

III.3 DISCUSSION

The contributions of this work should be analyzed in the context of indoor lighting systems, more specifically in classrooms and offices. Ongoing research shows similar results for the replacement of fluorescent lighting systems with LED technology lighting. It is clear that electrical energy savings can be achieved through replacement. In this sense, several studies have been carried out in recent years.

In [10] the energy savings that would be obtained if all CFL lamps were replaced by LED technology is analyzed, taking a commercial building as a case study. The economic feasibility of the project is also analyzed. In [23] electrical energy consumption levels between conventional lamps and LED lights were compared, measuring the savings in terms of power and energy efficiency, taking a commercial area as a case study. An economic analysis of the project was carried out in the work. A few years later, in [22], the energy efficiency using LED lighting in a bank building was analyzed. The illumination levels were analyzed and contrasted with the values indicated by international standard. In [21] a case study that considers the replacement of the lighting system in a Navy building was presented. Through the analysis of three different scenarios, the possible energy savings are shown. On the other hand, the simulation results and the energy diagnostic related to the modification of the layout showed satisfactory results in relation to the local technical standard.

However, to be more specific, the present work should be compared with lighting system replacements carried out in educational institutions. The works [24-26] can be cited in this regard. In [24] an analysis was carried out considering the technical-economic aspects of the lighting system replacement, taking as a case study the offices of a building of a university institution. The analysis showed that the replacement allowed a reduction in lighting energy consumption of more than 50%, which results in a reduction of annual operating costs. In [25], the effects of replacing lighting technology in indoor environments were studied. One of the study cases corresponds to the replacement of lighting system of indoor environments in a university building. The results indicate energy savings of more than 50 % associated to a reduction in installed power. Illumination levels were also verified according to local standard. In [26], the illumination levels in the work areas corresponding to a career in an institution of higher education were analyzed. These levels were compared with those specified in the local standard. The work provides recommendations for improving lighting energy efficiency and compliance.

In contrast, in this work an electrical energy saving value of approximately 60 % is achieved in the buildings analyzed. This may be due to the technological advancement of LED lighting systems. As a complement, the economic analysis shows that the time needed to recover the additional investment is less than one year, making the replacement proposal economically feasible. Furthermore, as a contribution, an analysis of the environmental impact has been made, presenting the calculation of GHG, although limited to the case of emissions in Argentina.

The opportunity to quantify the possible savings and make a more efficient use of electrical energy through concrete actions by the use of LED lighting, and especially in a public education institution, can be an incentive for this type of actions to be replicated in other areas. There is another potential opportunity derived from the previous one and it is closely related to increasing awareness of energy usage. This can be achieved if parallel to the technology replacement, an information campaign is carried out in order to raise awareness among the university community so as not to leave lights on unnecessarily. In other words, a campaign to achieve a change in people's attitudes and customs, taking advantage of technological change.

From the technological point of view, these actions can be complemented by incorporating auxiliary equipment, such as motion detectors, sensing of lighting levels, and use of timers, among others. These aspects correspond to the second implementation stage as part of the lighting system replacement policy in this case study.

In terms of electrical energy, it is clear that replacing conventional lighting technology by LED technology have significant advantages. However, the harmonic disturbances that the new system cause on the grid must be monitored. Depending on the quality of the devices, this impact may be different due to the filtering systems they contain.

As final remarks of this work, it can be said that this type of action is also directly in line with the United Nations Sustainable Development Goals for Latin America [41]. It supports Goal 7, "Affordable and Clean Energy," by improving energy efficiency. It is also in line with Goal 12, "Responsible Consumption and Production," by promoting the sustainable management and efficient use of natural resources. Moreover, this action contributes in part to several other goals. It supports Goal 8, "Decent Work and Economic Growth," by enhancing economic productivity through technological upgrades, since the proposed replacement of luminaires improves labor productivity. It also contributes to Goal 11, "Sustainable Cities and Communities," by reducing the adverse environmental impact of hazardous waste. Finally, it supports Goal 13, "Climate Action," by incorporating climate change measures into national policies, strategies, and planning through the replacement of lighting systems in public institutions.

Concerning the effects on human health, as mentioned in Section I, the flickering effect depends on the grid frequency and the equipment used to control the power supply of LED lights. The measurement of these variations and their attenuation is one of the problems facing LED technology in the immediate future, since each person may present symptoms of different intensity, or even not perceive them, although this does not mean that they do not affect its health.

IV. CONCLUSIONS

The replacement of the lighting systems technology in the buildings of the College of Engineering - UNCPBA allows to save approximately 60% of the electrical energy used for such purposes. This saving is equivalent to the consumption of 15 average households.

It is also verified that the light levels obtained with LED tubes are higher than those obtained with the existing system. However, the complete installation should be adapted to the lighting levels established by the regulations.

Furthermore, in relation to the electricity generation process, more than 17.2 tCO_2 can be reduced annually with this replacement. In addition to the reduction of greenhouse gases, the use of LED technology allows to reduce the volume of hazardous waste produced at the end of the LED light’s useful life.

In economic terms, the estimated cost to implement the technological replacement proposal and the return-on-investment time were quantified in a simplified fashion. Based on the obtained results, the SPBT is less than one year, indicating the proposal’s viability.

Based on the above factors and indicators it can be concluded that this first phase of replacement of the lighting system could be gradually extended to all the buildings of the College, and even to other public institutions, causing a positive energy and environmental impact. The action should be complemented with the addition of auxiliary devices for sensing the associated physical variables, and together with an awareness campaign in order to obtain a more comprehensive results derived from replacement action.

Finally, this action contributes to the sustainable development goals for Latin America, according to the United Nations agenda.

V. AUTHOR'S CONTRIBUTION

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Investigation: Fernando A. Benger, Cristian R. Ruschetti, Matias Meira and Silvano R. Rossi.
Discussion of results: Fernando A. Benger, Cristian R. Ruschetti, Matias Meira, and Silvano R. Rossi
Writing – Original Draft: Fernando A. Benger and Cristian R. Ruschetti
Writing – Review and Editing: Fernando A. Benger, Matias Meira, Silvano R. Rossi and Juan P. Pendones
Resources: Fernando A. Benger, Cristian R. Ruschetti, Matias Meira, and Silvano R. Rossi
Supervision: Cristian R. Ruschetti, Matias Meira and Silvano R. Rossi.
Approval of the final text: All authors.

VII. ACKNOWLEDGMENTS

The authors would like to acknowledge the authorities and personnel of the College of Engineering (UNCPBA) and the Scientific Research Commission of the Province of Buenos Aires (CIC).

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