Photovoltaic panels and led lamps: technical analysis of implementation viability

Painéis fotovoltaicos e lâmpadas de led: análise técnica da viabilidade de implementação

DOI:10.34117/bjdv5n10-113

Recebimento dos originais: 10/09/2019
Aceitação para publicação: 09/10/2019

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ABSTRACT

The world is moving towards clean energy consumption. In Brazil, large companies have already begun adapting to power microgeneration. However, photovoltaic panels installation studies in educational institutions for power generation are scarce and the legislation on this subject is not still comprehensive. One of the technologies that companies are adapting is LED light applied to interior lighting, but small buildings still have a strong resistance to replacement due to the high value of the initial investment. The main objective of this work is to analyze the feasibility of replacing fluorescent lamps, still widely used in Brazil, by LED technology and the significant reduction of energy consumption in a university building. In addition, the feasibility of installing photovoltaic plates for power microgeneration was studied, considering the classrooms as the focus of the project. It can be concluded that when the institution adheres to these types of technology, besides ensuring well-being to the users, it produces less waste, that is, less environmental impact and greater cost savings. Replacing fluorescent lamps with LED in the institution, the return on investment would be 5 months, and with the application of photovoltaic panels would generate a monthly savings of $1,829.52 over 25 years.

Keywords: Clean energy, Lighting, University building.

RESUMO

O mundo está caminhando para o consumo de energia limpa. No Brasil, grandes empresas já começaram a se adaptar à microgeração de energia. No entanto, os estudos de instalação de painéis fotovoltaicos em instituições educacionais para geração de energia são escassos e a legislação sobre esse assunto ainda não é abrangente. Uma das tecnologias que as empresas estão adaptando é a luz LED aplicada à iluminação interior, mas os pequenos edifícios ainda têm uma forte resistência à substituição devido ao alto valor do investimento inicial. O principal objetivo deste trabalho é analisar a viabilidade da substituição de lâmpadas fluorescentes, ainda amplamente utilizadas no Brasil, pela tecnologia LED e a significativa redução do consumo de energia em um prédio universitário. Além disso, foi estudada a viabilidade da instalação de placas fotovoltaicas para microgeração de energia, considerando as salas de aula como o foco do projeto. Conclui-se que, quando a instituição adere a esses tipos de tecnologia, além de garantir o bem-estar dos usuários, produz menos desperdício, ou seja, menor impacto ambiental e maior economia de custos. Substituindo lâmpadas fluorescentes por LED na instituição, o retorno do investimento seria de 5 meses e, com a aplicação de painéis fotovoltaicos, geraria uma economia mensal de US$ 1,829,52 em 25 anos.

Palavras-chave: Energia limpa, iluminação, construção de universidade.

1 INTRODUCTION

One of the main challenges facing by society is maximizing energy use and simultaneously reducing environmental impacts. Although Brazil is one of the most privileged countries in natural resources, with water, wind and abundant sunlight spread, almost all year
round, the use of renewable sources is still low (JOHN et al., 2002). Incentive policies for the implementation of renewable energy generation systems have been adopted in Brazil to enable energy security, diversify the energy matrix and encourage research in the sector. (DEMATTÉ et al., 2016).

One of the alternatives is the use of solar energy, mainly because of the Brazil receives abundant solar radiation, besides being considered an inexhaustible source of energy. Every day new researches are presenting different technologies for the utilization of this energy source. The National Electric Energy Agency (ANEEL), in Brazil, encourages the implementation of new renewable energy systems and also plays an essential role in encouraging the rational use of energy, seeking ways and solutions to optimize energy consumption. One of the measures that can be taken is the replacement of conventional lamps for LED lamps (MARINOSKI et al., 2004).

According to Brazilian Labelling Program coordinated by INMETRO there was a 40% reduction in the use of incandescent lamps from 2010 to 2016 in homes (AGÊNCIA BRASIL - EMPRESA BRASIL DE COMUNICAÇÃO, 2016). Thus, consumption by fluorescent lamps increased. However, this type of lamp depending on the building installation, is not necessarily the best way to obtain a good cost benefit and reduction in the electric bill. For fluorescent lamps, which besides being composed by mercury vapor or argon making difficult to discard and maying harm the environment, also require that the building installation has two auxiliary equipment for its operation, the starter and the reactor (CREDER, 2007).

The LED lamps have low power consumption and extended service life because they have no filament. These meet environmental requirements by not having mercury in its composition or any other type of gas harmful to the consumer and the environment, if incorrectly disposed of. They are low maintenance, have low operating voltage, dynamic color control and variable intensity, and also are more comfortable for the eyes because they do not emit ultraviolet and infrared light (CAVALIN, 2012).

Therefore, this study analyzed energy consumption, energy efficiency and technical-economic feasibility of replacing fluorescent lamps with LED lamps in a university building, evaluating the luminotechnical comfort. In addition, the feasibility of implementing solar panels in the building was studied, further reducing the cost of electricity.
2 JUSTIFICATIVE

The world is increasingly dependent on electricity and its generation needs to grow at the same rate. Once that the resources and technology are still limited, an alternative approach to this issue is the optimal use of energy. Can also cite cases such as between October 2013 and March 2014, in the state of São Paulo (Brazil), began a period of drought that affected the entire Southeast. According to the USP Agronomic and Geophysical Institute report, this episode was the second worst drought in the last 30 years, with 1216.8 mm accumulated, being 13% below the climatological average. In addition to worrying the population and directly installed companies in the region, one of the most worrying consequences is the impact on Brazilian energy production (INSTITUTO DE ASTRONOMIA, GEOFÍSICA E CIÊNCIAS ATMOSFÉRICAS, 2014).

One of the economic measures, established by Interministerial Ordinance 1.007/2010, was to prohibit the commercialization of incandescent light bulbs, helping to stimulate the adoption of more economical and durable options, such as LED, already widely adopted in other countries. In Brazil, electricity consumption in residential and commercial buildings, as well as public buildings corresponds to approximately 50% of the total electricity consumed in the country and the largest end uses of energy in commercial and public buildings are the artificial lighting, 49% and air conditioning, 35% (ELETROBRAS, 2011). In non-residential buildings due to needing for environmental comfort because of specific activities, productivity issues and visual comfort for work tasks, the energy consumption in lighting is generally higher (AMORIM, 2004).

In educational institutions, natural or artificial lighting requires good attention once that it is directly related to the development and teaching-learning process. Incorrect sizing of natural light and artificial lighting system has numerous consequences for the health and welfare of the user (HYBINER, 2015). The importance of good lighting is not limited to illuminating the environment, when appropriate provides safety, comfort, better income from activities and reduction of errors and accidents (CAVALIN, 2012). The use of good artificial lighting is of great importance in educational institutions, because even in periods with higher light incidence it is used.

There are currently several technologies that helps reduce energy costs and ensure comfort in the environment. An example of this is LED technology, which can be used to illuminate...
the indoor environment, providing acceptable visual comfort where is installed. Another method that can be used together is photovoltaic panels as cogenerators of electric energy (INSTITUTO NACIONAL DE METROLOGIA, QUALIDADE E TECNOLOGIA, 2016).

3 METHODOLOGICAL PROCEDURES

3.1 STUDY PLACE

The study place was a building of a Higher Education Institution (HEI) located in the interior of São Paulo. The room selected for the study were the rooms with less interference from external light, which are on the third floor. It can be concluded that the third floor has this characteristic due to its distance from the streets, the light-emitting motor vehicles and the streetlights poles that illuminate them, and also from the reflection of the lights on the objects. Thus, when measurements were made it resulted in more accurate artificial illuminance emitted by the room lamps with little external interference.

The measurements were taken on the third floor of the building, between 20 and 23 hours, and took place from November 27 to December 15, 2017. It is important to note that on those days the Southeast was at daylight saving, therefore the sun went down completely around 8pm.

3.2 DATA COLLECTION

For the economic analysis of the current fluorescent lamps of the HEI, the number of luminaires was surveyed, data on operating hours and energy consumption were obtained.

Initially, the rooms sizing was surveyed with the electronic tape Bosh GLM 80 and the points needed to obtain the average illuminance were mapped. Thus, the luminotechnical comfort and the economical viability to replace the fluorescent lamps by LED were analyzed. In Figure 1 it is possible to observe the average sizing of the rooms and the points chosen to position the luxmeter following the point-to-point method described in NBR 5413 (ABNT, 1992) and the verification method according to NBR 5382 (ABNT, 1984).
Figure 1. a) Dimension of the points determined for the point to point method; b) Verification method according to NBR 5382- Interior Illuminance Verification.

Source: Authors, 2018.

To obtain the luminous intensities at the desired points, the digital lux meter LDR - 225 was used, which was positioned at the height of the work area, desks of classrooms, with 0.7 meters.

3.3 LIGHTING CALCULATION METHODS

To determine the number of luminaires, the Lumens Method was used. The way to perform this method is from Equation (1).

\[
n = \frac{S \times E_m}{\mu \times d \times \phi}
\]

Where:

- \(n\): number of lamps;
- \(E\): illuminance or illumination level in lux;
- \(S\): enclosure area in m\(^2\);
- \(\mu\): coefficient of use;
- \(d\): depreciation factor or coefficient;
- \(\phi\): luminous flux of each lamp.

According to the Lighting Manual (ELETROBRAS, 2011), the depreciation factor according to site maintenance for dirty or poorly maintained environments is 0.6 to 0.8 which is characterized for clean environments. The Utilization Factor is a tabulated value, which considers the area factor (K) and the reflectance of the ceiling, wall and floor. Useful ceiling
reflectance ranges from 60% to 90%, for 30% to 80% walls, and 10% to 50% floors, according to ISO / CIE 8995-1 (ABNT, 2013). To calculate K was used Equation (2).

\[ k = \frac{C \times L}{H \times (C + L)} \]  

(2)

Where:

k: Factor for determining the number of points required for measurement; C: length of the environment (m); L: width of the room (m); H is the height between the work plane and the bottom of the window lintel (m).

This method was used to verify if the number of current lamps complied with the parameters suggested by ISO / CIE 8995-1 (ABNT, 2013). Using this calculation, the average illuminance value of 500 lux, ideal average illuminance for classrooms at night, determined by the standard.

3.4 ANALYSIS OF LUMINOTECHNICAL COMFORT

To analyze the luminotechnical comfort in the rooms, the Verification and Point to Point Methods were used.

3.4.1 Verification method

In this method, it analyzed if the average light intensity was in accordance with the standard and if the number of luminaires was in accordance with NBR ISO / CIE 8995-1 (ABNT, 2013). Thus, 12 strategic points were obtained in relation to the luminaires in the classrooms and thereby, amount of lux emitted was measured, as shown in Figure 1b. Figure 2 shows the model described in NBR 5382, which shows the reference points and the letters of the corresponding points.
To calculate the average illuminance, Equation (3) was used:

$$\text{I}_\text{lmMed} = \frac{(R.N.(M-1)+Q.N+T.(M-1)+P)}{(M.(N+1))}$$

(3)

Where:

R: Average of points r1, r2, r3 and r4; P: Mean points p1 and p2; T: Mean points t1, t2, t3 and t4; Q: Average of points q1 and q2; N: number of luminaires per queues. M: number of queues. The values of points R, P, T and Q are measured in lux.

The digital LDR - 225 luxmeter was used for the function that obtains the points automatically. The equipment was positioned at the points exemplified in the sketch of Figure 1b and at a height of 0.7 meters, working area. Then, the lux meter was connected to the computer and generated several tables in XLS format with the data collected room by room. Thus, the ideal points for the calculation of the average illuminance, Equation 3, were separated. With the result of Equation 3, the number of lamps was calculated through Equation 1. Thus, we compared the actual number of lamps in the room. with the optimal value scaled.

3.4.2 point-to-point method

The Point-to-Point Method was also applied to determine if the luminous flux was distributed evenly throughout the room and with the MatLab software, an area plot with the
midpoints was performed and the values in lux were quantified by color. the thermal comfort. According to NBR 5413 (ABNT, 1992), for the calculation of daylighting, the points for measuring the average illuminance should be arranged, dividing the indoor environment into medium areas taking into account the height between the work plane, the part lower the window lintel and the dimensions of the environments, according to Equation 2.

Where:

\[ k \text{ is less than 1, it represents 9 points; between 1 and 2, 16 points; between 2 and 3, 25 points; and greater than 3, represents 36 points.} \]

To obtain the mean illuminance value, 25 midpoints were determined and distributed equally in the room (Figure 1a). With the digital luxmeter, in the same configuration described in the method of NBR 5413 (ABNT, 1992), 4 values were obtained at each point and then averaged the value per point. With the average illuminance in this method, it was possible to make the comparison between the Point to Point methods and the Verification Method.

3.5 LED LIGHTING INSERTION AND ECONOMIC FEASIBILITY

Calculations were performed to determine the correct dimensions to be used for greater use. A market research was then conducted to select the most cost-effective lamp model. Thus, it was possible to analyze the technical feasibility of the application of LED lamps, tending to reduce the consumption of CCT.

To calculate the annual cost, Equation 4 was used.

\[ \text{AnnualCost} = \frac{(N \cdot \text{Pot} \cdot N \cdot D \cdot P)}{1000} \]  

Where:

\[ N \] is the number of luminaires; \( \text{Pot} \) is the power per luminaire in watts; \( H \) is the total hours of operation per day; \( D \) is the total use in days per year; and \( P \) is the price in reais.

It is noteworthy that the bill should be divided by 1000 because it is a power calculation in Watts, but the cost to the utility is given in kilowatt.
3.6 SOLAR PANEL SIZING

Initially we found the study site solarimetric index, available on the CRESES B website, through the SunData program, using latitude and longitude, in which is presented a graph and monthly average daily solar irradiation table [kWh / m².day] by month. Thus, the sizing of the panels was performed by calculating the monthly energy consumption by Equation (5) and the number of solar panels by Equation (6) (Dematte et al., 2016).

\[ E_m = Ep \times 30 \]  \hspace{1cm} (5)

\[ N_p = \frac{E_{\text{required}}}{E_m} \]  \hspace{1cm} (6)

Where:

\( E_m \) = Monthly energy (kWh); \( E_p \) = Energy produced (kWh); \( N_p \) = Number of panels; \( E_{\text{required}} \) = Energy Required (kWh).

Then, a market research was conducted to consider the value of implementing panels for the microgeneration of energy in the building.

4 RESULTS AND DISCUSSION

4.1 DATA OBTAINED

The dimensions of the rooms were obtained with the electronic tape measure GLM 80, which showed that the rooms have the same pattern on average. There was a slight variation of 20 cm between the rooms, but this did not affect the result of the number of place lamps. The dimensions found in 13 rooms were 8m x 7.30m, called standard rooms and in the other two, larger rooms, 7m x 9.5m.

The standard rooms contain 9 2x32 W white overlapping fluorescent tubular t8 / t10 luminaires, with reflectors and flat painted plate fins, for use in environments where medium obfuscation control is required, such as libraries, shops and auditoriums. Figure 3 shows the 2x32 W luminaire. It also has 4 1x28 W white overlay luminaires directed towards the board with a single lamp.
Currently, these luminaires use lamps from Osram T8 FO32W / 83 which have the following characteristics, according to the catalog supplied by the manufacturer (OSRAM, 2018): Power: 32 W; Luminotechnical Flow: 2700 lm; Color Temperature: 3000 °C; Color Reproduction Index (IRC): 80-89; Diameter: 26 cm; Length: 1200 cm; Base: G13.

4. 2 NUMBER OF LAMPS IN THE STANDARD ROOM

Through the Verification Method it was obtained average illuminance values per room with the average illuminance of the classrooms was 520 lx, there is a good maintenance in the classrooms, since HIE has a periodic maintenance of the them and the installation has a Constant cleaning. The values used for the depreciation factor were 0.8, the luminous flux factor of 2700 and area of 58.4 m². The utilization factor is granted by the vendor through a table (ITAIM, 2018). In this study, a value of 0.58 was used because the ceiling was painted black, performing an interpolation between the values 751 and 551, with K equal to 2, corresponding to the values of 0.6 and 0.59. The reflection value for the wall would be 50%, the floor 30% and the ceiling as black 30%. Consequently the value 351 corresponds to 0.58. The average illuminance values of the rooms found ranged from 480 lx to 550lx, and the standard states that for the room to use them at night time an average illuminance of 500lx should be obtained. Pereira (2012) in his study determined the average illuminance in a public educational block during the day and night periods. Unlike of this work, the classrooms at night were not suitable for use, with an illuminance of 150lx.

For the studied rooms, the ideal number of luminaires would be 12, resulting in 24 lamps, however it should be noted that this number could be lower if the ceiling were not black and the luminaires were better distributed. With the ceiling painted in a more reflective color, for example white, the number of lamps needed could be reduced to 20, as the utilization factor varies depending on the color of the ceiling, wall and floor. As the luminaires are not
distributed with equivalent spacing throughout the room, this results in areas where the light intensity is 700lx.

4.3 ANALYSIS OF LUMINOTECHNICAL COMFORT

To analyze the luminotechnical comfort, we initially defined the number of points required from Equation 2, resulting in $k = 2$, concluding that it was necessary to use 25 points.

With the point values, as illustrated in Figure 4, and the dimensions of the points, the graph of the luminotechnical comfort was generated using the Matlab software, with the Smooth function.

According to ABNT / CB-03 1st PROJECT 03: 034.04-100 and ISO / CIE 8995-1 (ABNT, 2013), for night rooms the average illuminance should be 500 lx. In the graph it is possible to observe regions where $E_m$ is above the norm, in most points it has the value stipulated by the norm and in the back of the room the brightness is less than 500lx. In the back of the rooms there is a 1.5m plaster projection of extension, which has no lamps and thus some desks in the night are poorly lit. In this region, where there is no direct illumination in the night, if the environment depends only on artificial lighting, it is not enough to obtain a luminotechnical comfort in the current room conditions.

Importantly, in the previous and currently canceled standards, NBR 5413 (ABNT, 1992) and NBR 5382 (ABNT, 1984), the average illuminance required was 300 lx for night classrooms. Since the projects were carried out when these standards were in place, the room is designed correctly and attended to the standards of the time. However, in areas with illuminance much higher than the average determined by the standard, it may cause discomfort due to obfuscation.

Ritter et al. (2010) performed the same type of comparison in the classrooms of the Pelotas Visconde da Graça Campus, of the Federal South Institute, however the external illumination influencing the analyzed rooms was analyzed. At 18:30, which was last time analyzed by the author, in this case, which has the least solar influence, it was possible to observe that there are 700 lx peaks in some points of the room, but unlike the case studied in this work, but unlike the case studied in this paper, these points were near the windows that are exposed to the sun. The points with a value greater than 700lx analyzed here is due to the
proximity of the lamps leading to an excess of illumination and may even overshadow the student.

Pereira (2012) presents the graph of the lighting scheme of a classroom of the Federal University of Campina Grande in the morning, in which the level of illumination is homogeneous, close to the value determined in the standard. However, in the nightly period the values were much lower than expected, unlike the HIE classrooms studied. A study was carried out in a third floor room in which every two hours, from 8:30 to 20:30, the average illuminance was measured, concluding that even during the day classroom 309 maintained an expected illuminance. It is important to note that classroom 309 was located near the University façade, so even at night it had an average illuminance of 539 lx, which is within the expected value of the current standard.

4.4 ECONOMIC VIABILITY

Regarding the economic viability, it should initially be considered that the first challenge is the cost of the LED lamp, because, on average, the cost of the T8 32w lamp used in IES is currently R $ 7.00, while its competitor, the LED lamp, is found wholesale for R $ 27.00, this value varies by brand, however it is very important that the LED purchased is a good brand for its impact on reducing energy expenditure to be effective.

Importantly, during school holidays the university continues in use, but has reduced consumption.

If the calculation of the cost difference of the energy bill is performed, the result obtained will be positive for the LED, because the consumption varies in relation to the lamp power and this is in turn a function of current and voltage. Therefore, if there is a decrease in the power used (in this case, 32 W by 18 W) the current will be lower, that is, the energy consumption will be lower, thus reducing the amount of energy spent.

Considering 15 classrooms per floor, the total number of lamps in IES classrooms is 1484 lamps, whereas there are 4 floors with 13 standard-size rooms and 2 larger rooms and one floor with 4 standard-size rooms and a larger room, results in a total of 260 single luminaire lamps and 1224 dual luminaire lamps.
Approximately 16 hours of use per day in 253 days per year are required at HEI. The cost of kW/hr, according to the local energy distributor's tariff cost table for trades, is approximately R$ 0.48. Considering the power of the fluorescent lamp with 30% of the reactor, it has 41.6 W.

Calculation for fluorescent lamps:

\[
\frac{872 \times 83.2 \times (16) \times 253 \times 0.48}{1000} = (\text{fluorescent}) = R\$ 140,968.33
\]

Calculation for LED lamps:

\[
\frac{872 \times 16 \times (16) \times 253 \times 0.48}{1000} = (\text{LED}) = R\$ 27,047.12
\]

The annual cost would be reduced by R $ 113,921.21 per year. If was consider the value of the lamp investment, which will be approximately R$ 40,068, the return on investment is expected in less than one year. Assuming that the monthly cost equals the investment would begin to have financial return in the 5th month, considering only the lighting expenses.

The annual cost would be reduced by R $ 113,921.21 per year. If the cost of disposal is relevant, even if they are donated, the value of transportation should be considered for disposal of these lamps. However even at this cost the returning would remain the same. Care should be taken with proper disposal as this type of lamp has mercury in its composition and cannot be disposed of in any way in the environment. Improper disposal of fluorescent lamps can contaminate the soil, air and water due to mercury present and thus harm human health. The entire process for its disposal must be done in a technically safe and appropriate manner. The destination must not be landfills, in natura release, grounding, burning or incineration process and should be destined for recycling, so that it does not harm the environment, according to Procel Lighting Manual (2011). In the region where IES is currently located, there are five stations for proper disposal of lamps. Another viable option is to donate these lamps that are still in use to charities.
Thus, the investment is worth and seeing that besides the short deadline for return, IES would still be resembling the most current building projects, which use only LED lighting.

4.6 PHOTOVOLTAIC PLATES

The dimensioning of the photovoltaic plates was calculated by kW/h per month in 2016, provided by the faculty, the solarimetric index in the region of Campinas (CRESESBS / CEPEL, 2018) and the efficiency of the microgenerator panel 83%, considering lossing by generation and transmission. In Figure 4 it is possible to observe the solarimetric index of the longitude and latitude of the University address, obtained from the CRESESBS - Reference Center for Solar and Wind Energy - Sérgio Brito / CEPEL - Electric Energy Research Center website.

Figure 4. Solarimetric index of the study site.

Source: CRECESBS/CEPEL

The power microgeneration project can be applied to the upper area of the university building as it is a poorly accessible area, easy for maintenance, high exposure to solar radiation and considerable size for panel installation.

With these values, a market research was conducted and determined that the best board, due to the consumption of Watts/month, is the Solar Grid-Tie Kit 2376 kWh/Month for Connection to the Electricity Network (380V Three Phase). Unlike Siqueira (2015), of 220V, the dimensioning to be considered in this work was taking into account the voltage of 330V, because the faculty has, due to the size of the building, a three-phase circuit breaker. In this case the quoted value of the panels with the GRID inverter was R$ 61,390.00 (Minha Casa
Sol, 2018), however this value can be negotiated. Using this, assuming an average system production of 2376 kWh / Month, would generate Savings per Month of R $ 1,829.52, as shown in the 25-year profitability graph (Figure 5).

![Profitability in 25 years](image)

Figure 5. Profitability according to the manufacturer in 25 years, as it is its lifetime.

Source: Minha Casa Sol, 2018.

In order to carry out this project, besides the basic costs with the panels, the inverter and the labor for installation, the maintenance cost along the use must be included. The manufacturer advises that the plates be serviced annually, cleaning so that they do not accumulate dirt and decrease the efficiency. However, there are factors not accounted for in the calculation of economic viability, such as the fact that with this system there were no cuts in power supply and the use of the generator will be almost nonexistent, indirect benefits as defined by Xavier (2015). It also describes other factors that are not accounted for in economic viability that are beneficial externalities such as reducing the thermal load of buildings, the emission of no pollutants from this system and may alleviate the distribution system.

Just like fluorescent lamps, one should consider discarding this material after 25 years of use. Research is currently being done, however there are not many results on the disposal of this material (Xavier, 2015). The ideal for now being to dispose of properly, contact the manufacturer and return them. As Souza (2014) argues, Brazil is not yet prepared for this new type of renewable energy use, Brazilian regulations still present uncertainties. However, following in the footsteps of countries such as Germany, China and the United States (SOUZA, 2012), with greater adherence to this type of energy, more Brazilian companies invested capital and more legislation will be made to protect a new era of clean and renewable energy.
5 CONCLUSION

It is concluded that even being a high initial investment for educational HEI, the adherence of LED technology is economically viable. In addition, if photovoltaic panels were installed for the purpose of generating energy for their own consumption, selling the surplus to grid or storing in generators, it would be possible to implement with a quick financial return on investment to adapt the new technology. Therefore, the building is adapting to the technologies present in the market, becoming sustainable, in the sense of generating the energy consumed, and using resources that generate minimal waste to the environment.

From the technical point of view, it was also observed that the exchange of lamps becomes feasible, although it is necessary to plan the disposal of fluorescent lamps in order to it is not harmful to the environment.

Another fast and cost-effective way to adhere is to paint the ceilings with a more reflective color, for example white, as the black color absorbs a part of the light and does not allow for a large reflectance, wasting more energy to illuminate the ceiling same area. It could be also removed current sun shields that are fixed to the exterior windows of the building and replaced with curtains that users could adapt to the need. Since nowadays even with the shields are fixed and cannot be directed against the sunlight, there are places in the rooms where the glare due to sunlight is great and there is no ideal luminous technical comfort.

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