Energy Efficiency Analysis in a Higher Education Institution in Manaus - Amazonas

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Abstract

Thinking about solving the problem of high consumption and high cost in the electricity bill, this study proposes to present proposals to increase the energy efficiency of the site. In this sense, it is proposed an energy efficiency analysis of a Public Higher Education Institution in the Municipality of Manaus, Amazonas. A building survey was performed on the appliances and components of the building's electrical system, as well as an assessment of electricity bills to measure consumption. In order to verify voltage, current and power, electric measuring instruments were used to elaborate proposals aiming at increasing the energy efficiency of the site. Through the results obtained during the building survey at the IES, it was possible to observe the anomalies of the systems and indicate proposals for repair or replacement of equipment to increase the energy efficiency of the building. From the results obtained from the invoice it was possible to propose a new value of demand contract and by comparing the collected data, we identified the appliances that make the electric system less efficient, in this case, the air conditioners. Recurring payment problems with overconsumption were encountered. Adhering to the proposal of a new contract value with possible annual savings of R $ 22,543.92 referring to the payment of the demand portion in the electricity bill. It is also proposed to replace current lamps with LED tube lamps, reducing energy consumption by 9,122 kWh / month and saving R $ 3,263.57 per month. As for the proposal presented for the HVAC system, given the exchange of existing appliances for new and energy efficient, was not viable. Despite representing a reduction of 41869.91 kWh / month, the expected investment is not paid.

Keywords: Lighting, Power factor, Electrical system;

1. Introduction

Since its discovery, electric power has become a primordial element in human life. Unquestionably, this asset provides comfort and help in the social and economic development of a country.

Energy is used in simple household appliances or in systems made up of more complex ones, which bring together various equipment. These devices and systems, during their operation transform forms of energy, part of that energy is lost due to environmental conditions and the characteristics of the materials used during this process [1].

In order to solve this problem, energy efficiency emerges, which offers the possibility of using less energy to provide the same services, as well as the simple use of electricity consciously and rationally, which is to achieve the best possible cost benefit [2].

In other words, "energy efficiency measures the quality of energy use for the purposes it serves society" [3].

It was considered, within the framework of the PNE 2030 national long-term energy plan, as an energy gain through autonomous efficiency progress, and in accordance with the actions taken by the EPE in the preparation and biennial review of the PNE [3].

Regarding the laws and legal aspects that deal with the theme of energy efficiency, Law N °. 9.478, August 6, 1997, in Article 1, item IV, states that one of the principles and objectives of national energy policy is "to protect the environment and to promote the conservation of energy".

According to decree No. 9.864 of June 27, 2019, in its article 1: "The maximum energy consumption levels or minimum energy efficiency levels of energy-consuming machines and appliances manufactured or sold in the Country, and of buildings constructed there, shall be regulated by the provisions of in this decree, based on technical indicators, by the steering committee under the coordination of the Ministry of Mines and Energy (MME) ".

For the national electricity sector were considered by 2030, 5% reduction due to autonomous progress. In addition to this 5% reduction in demand, another 5% imposed by additional target, thus requiring the implementation of energy efficiency, detailed in the PNE [3].

Several countries have employed actions that promote energy efficiency, as well as incentives for the use of alternative sources of energy (wind, solar, hydro, etc.) according to data from the Ministry of Mines and Energy (MME) ".

For European Union (EU) for example, it is increasingly important to reduce energy consumption and waste. In 2007, EU leaders set the target of reducing EU annual energy consumption by 20% by 2020. Energy efficiency measures are seen as a means of achieving sustainable energy supply by reducing greenhouse gas emissions. , improving security of supply and reducing the cost of imports, as well as enhancing EU competitiveness.

Energy efficiency is therefore a strategic priority of the energy union and the EU promotes the principle of energy efficiency where the future framework of post-2030 action is being negotiated [4].

In Brazil, the federal government created the National Electricity Conservation Program (Procel) in 1985, under the command of the Ministry of Mines and Energy (MME) and executed by Eletrobras, with the purpose of reducing energy losses, the costs of and sectoral investments [1].

The Procel Seal indicates to the consumer which products have the best energy efficiency levels in their category (ceiling fans, refrigerators, etc.). This way, it is possible to know if the product consumes less energy than another equivalent without the seal [1]. A good way for consumers to check if the desired product is economically and environmentally viable.

Thinking about solving the problem of high consumption and high cost in the electricity bill of a unit, this study proposes to present proposals to increase the energy efficiency of the site.

From this context, the study presents as its objective proposals for improvement in the electric energy management of a public higher education institution, in the city of Manaus, Amazonas.

2. Materials and Method

2.1 Type of study

A case study was conducted as a research strategy. The case study investigates a contemporary phenomenon within a given real-life context, especially when the boundaries between the phenomenon and the context are not well defined, thus facing a technically empirical situation in which there will be variables in identification and analysis. of data to achieve results [5].

2.2 Area of study

This study was carried out in a public institution of higher education, in the city of Manaus-AM.

The public institution, autonomous in its educational policy, has the mission of promoting education, developing scientific knowledge, particularly about the Amazon, together with the ethical values capable of integrating man into society and improving the quality of human resources in the region. where it is inserted.

2.3 Data collect

Initially, we conducted bibliographic research as proposed in regulatory standards on efficiency and on segments of the electrical system that may undergo changes to reduce electricity consumption such as lighting and air conditioning; building electrical installations; guides; technical manuals for energy efficient equipment; and tariff structure based on the Brazilian regulatory standard.

It followed the survey of the installed load in the building, analysis of electricity rates, the collection of data related to the site consumption, as well as the analysis of system characteristics and proposals for efficient use in energy.

For the economic evaluation stage, the investment analysis methods were used: Net Present Value (NPV) and Capital Return Time (TRC).

The NPV is the algebraic sum of all discounted cash flows for the time T = 0 determined by the equation:

$$NPV = -k + \sum Ni = 1 * Fci / (1 + TD) i. \text{ (Eq. 1)}$$

Where: k represents the initial investment; Fci, the discounted cash flow that corresponds to the difference between the income and expenses realized in each period considered in R $; TD, the discount rate; i, the time in years and N, number of periods.

The CRT was calculated from:

$$TRC = k / RM. \text{ (Eq. 2)}$$

Where: k represents the initial investment; RM or monthly return (amount saved per month).

For the survey of installed loads, it was necessary to identify what types of equipment are working on site, the number of hours, hours of use and the power consumed of each device to determine the share of consumption that each has in the total energy. electric

The survey of installed loads was carried out in August and September 2018. To obtain the data was verified at each building location, where for the lighting system: the types of lamps used, the type of reactor for fluorescent tubes. , quantity of each lamp and reactor, their rated power and hours of use per week at the most and least requested times.

For the HVAC segment, the type of appliance (Split or window), manufacturer, class, if there is a PROCEL rating seal, cooling capacity in BTU / h, quantity, rated power and number of usages per week at peak and off-peak times. Appliance time (h / w) was used due to the classrooms and laboratories operating at different times each day of the week. These hours were determined via the ensalement worksheet provided by the unit's quality department.

In this study the used power values of the devices were nominal power values (values specified by the plate manufacturers close to the actual power values).

From the power data obtained or from standard values specified in manuals, the load was divided into 10 groups: air conditioning (window, split and central); lighting (2x40 W, 2x20 W, 2x16 W luminaires, 100W incandescent lamps and 40, 45 and 25 W electronic compact lamps); drinking fountain; coffee machine; computers and notebooks; refrigerators; printers; projectors; microwave and laboratory equipment.

The instruments used for data collection were: clamp meter ET-3200A to measure voltage and current; Wattimeter ET-3200A pliers to measure power values given the condition of many constants and metric tape measure to measure the study area.

To collect the data from the lighting system, a Minipa model MLM-1010 digital luxmeter was used.

In order to verify the consumption of electricity bills, it can be verified in which months there is a higher energy consumption of the site, as well as which factors are causing additional costs due to penalties in the legislation on the composition and collection of the electricity tariff. .

Following the lighting and air conditioning system began by collecting data on the luminous flux of the lamps used in the lighting system in operation of a certain area chosen for the analysis.

According to ABNT NBR ISO / CIE 8995-1 2013, each environment has a certain level of lighting to be suitable for the accomplishment of a given task.

Illuminance is measured in LUX (lx), the unit of measurement used by the luxmeter, using the equation.

$$lx = lm / A \text{ (Eq. 3)}$$

Where: lm means incident lumens A (m2) area of incidence.

To measure this luminous flux following criteria established in ISO / CIE NBR ISO / CIE 8995-1 which determines the distances between the illuminance measurement points.

To analyze the system characteristics and proposals for energy efficiency, the building's electrical system analysis was performed, such as: how much each segment of the system consumes electricity; the appliances that make up each segment of the electrical system efficient and, if well used.

Measures can be developed to increase energy efficiency and stipulate through technical calculations how much each proposal will bring about reduction in electricity consumption and thus perform economic analysis.

3. Results and Discussion

The survey of installed load made it possible to determine the installed power of each group of the system (lighting, air conditioning and others) making it possible to calculate the electricity consumption per month, establishing the representation of each of these inputs (figure 1).

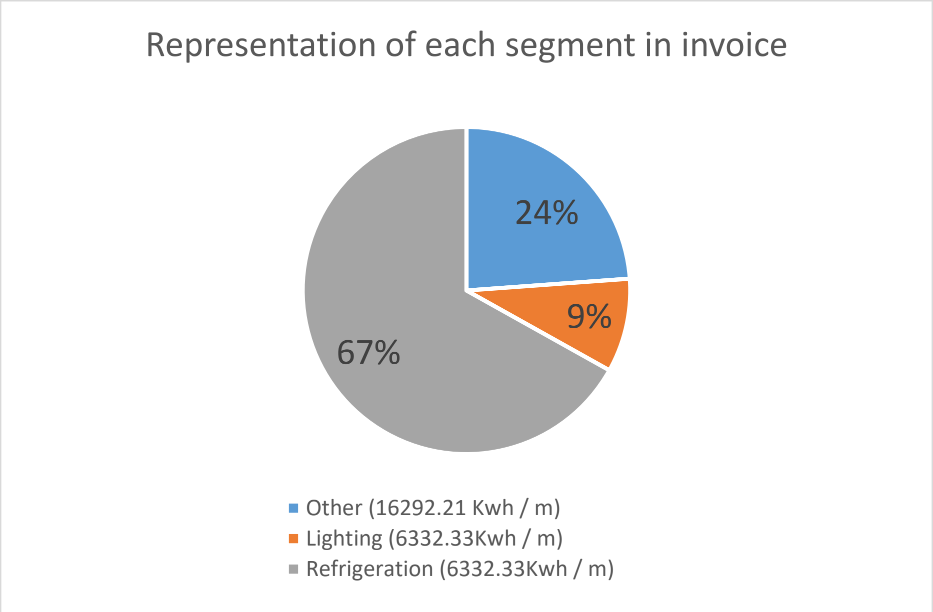

Figure 1 - Representation of each segment on the May 2018 invoice.
Source: Own authorship (2019).

As observed, the largest portion of the tariff composition is in the HVAC sector, representing R $ 45,702.08. The second largest portion is in others (office equipment, electrical machines, appliances, consumption of the outside of the building) this amount represents $ 16,292.21 and finally the lighting sector, representing $ 6,332.33. Through this study it was possible to analyze the difficulties of each segment and present solutions for each one, without the need to turn off the electrical appliances (table 1).

Table 1: Tariff composition.

SECTOR	VALUE	%
COOLING	45.702,08	67
OTHERS	16.292,21	24
LIGHTING	6.332,33	9

Source: Own Author (2019).

Looking at the table, the tariff composition of the refrigeration sector represents the largest expense (67%) in the final amount of the electricity bill and the lighting sector only 9%. This result is not surprising, as the cooling and air conditioning system is one of the main challenges for reducing electricity consumption. Air conditioning systems account for about 20% of commercial electricity consumption.

For the residential sector, air conditioning accounts for 33% of consumption, where equipment has 10% of the country's total electricity consumption, with the compressor being the critical component in the refrigeration cycle [6].

Invoices represented the possibility of reducing energy supply expenses. It was observed that the institution's demand contract, in ten of the twelve months targeted by the study, was penalized, given the excess representing an annual cost of R $ 80,360.64, given the saturated demand values.

Given this, the average value of 737 kW was calculated as the ideal value of demand to be contracted for the current consumption situation, where this value was simulated, with data from the twelve energy bills. It can be seen that the amount consumed by the university exceeds by some months the value proposed for a new demand contract, but does not exceed the tolerance value allowed by the concessionaire. If the demand contracted by the unit was 737 kW, no penalty would be paid for excess demand consumed. This represents an annual cost of R $ 57,816.72, a saving of R $ 22,543.92 over 12 months.

Considering that the demand consumption profile of the next twelve months is close to the months that have elapsed and using the facilities offered by ANEEL 456 resolution, it is recommended to request the power concessionaire, through the immediate revision of the supply contract. . This measure does not require economic evaluation as this resolution does not provide for any type of investment to request revision of the supply contract [8].

In the analysis of a possible change of the tariff modality, the simulation of the energy tariff billing of May 2018 showed that if this month were billed in the blue horo-seasonal mode, the tariff value would be R $ 69,198.68 against R $ 60,831.14 of the amount invoiced in green hourly mode, ie, would be paid R $ 8,367.54 more with the blue hourly seasonal mode.

This billing simulation was also performed for the previously calculated demand value (737 kW) and the values obtained in the simulations were R $ 66,013.99 for the blue time-seasonal mode and R $ 65,630.05 for the green time-period, being paid R $ 383,94 more in the blue time-seasonal mode.

From these simulated tariff values for the month of May we can conclude that the green hourly seasonal tariff should be maintained as it generates a lower energy tariff value expenditure, but only the one month simulation should not be taken into consideration. For this decision making, it is necessary to simulate all other invoices used in the study.

Carrying out the load and the analysis of invoices, were analyzed the lighting and air conditioning systems of the building, from the data obtained establishing the current situation of the system.

Currently 94% of the university's lighting system consists of tubular fluorescent lamps representing a consumption of 16640 kWh / month and the energy bill a cost of $ 5,950.47, these lamps compared to LED tube lamps are 25% less efficient. .

The LED uses 82% less electricity than an incandescent light bulb. A domestic LED light bulb has a lifetime of 50,000 hours, compared to 1000 hours for incandescent light and 6000 hours for fluorescent light, a technology that makes it possible to reduce the amount of lamp changes or maintenance costs [7].

The proposal presented to increase the energy efficiency was to replace the current lamps with LED tube lamps, for this, it was verified the specified power values and illuminance conditions that each lamp and the place. By replacing light bulbs, a reduction of 9122 kWh / month and a saving of R $ 3,263.57 in energy tariff were achieved, making the proposal economically viable.

From the calculations made for the lighting system, it was found that the NPV is positive from the second year, with a profit of R $ 3,263.57 and with a total value for 5 years of calculation the profit of R $ 59.374, 12.

The CRT is shorter than the life of other lamps and is an economic indicator used in the study, indicating that the investment is being made.

In the HVAC system, it was found that the university has 15 window type air conditioners, with more than 10 years of use, in replacement process.

More than 50% of its system is composed of 48000 BTU / h devices, represented by 88 splits devices, of which 45 have the PROCEL seal of efficiency, being 24 A-rated and 21 B-rated devices. which do not have a PROCEL seal represent a consumption of 4,169 kWh / month and the energy bill represent R $ 14,924.7. Replacing the air conditioners indicated in the study will bring a reduction in energy consumption of 41869.91 kWh per month and a savings in the energy tariff of R $ 2,831.37. In economic calculations for air conditioning, NPV was negative, but TRC presents the calculated value less than the useful life of the device being a non-viable investment.

4. Conclusion

Through the results obtained during the building survey at the IES, it was possible to observe the anomalies of the systems and indicate proposals for repair or replacement of equipment to increase the energy efficiency of the building.

Through the analysis of the results obtained from the invoice it was possible to propose a new value of demand contract and by comparing the collected data, we identified the appliances that make the electric system less efficient, in this case, the air conditioners.

Recurring payment problems with excess demand consumption have been identified. Adhering to the proposal of a new contract value with possible annual savings of R $ 22,543.92 referring to the payment of the demand portion in the electricity bill.

It is also proposed to replace current lamps with LED tube lamps, reducing energy consumption by 9,122 kWh / month and saving R $ 3,263.57 per month.

As for the proposal presented for the HVAC system, which was the exchange of existing appliances for new and energy efficient appliances, was not feasible. Despite representing a reduction of 41869.91 kWh / month, the expected investment is not paid.

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