ENERGY EFFICIENCY IN LIGHTING WITH THE USE OF NATURAL LIGHT

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Abstract. *The analysis of the global energetic needs in an office building has to take into account the daylight and artificial lighting. In order to achieve both high-energy efficiency for lighting systems and use of natural lighting was developed a case study in a building were is in a building where it is installed a telecommunications equipment testing laboratory. The needs are high accuracy visual activities and temperature stability. The artificial lights and natural lighting coming from the windows lighting influence the luminous and thermal behaviors of a room. Was analyzed the conditions of the position of the building on the solar path, the opening of windows and the conditions of irradiation on the walls with actual openings. Was analyzed the currently lighting systems efficiency on the needs of lighting in accordance with the environmental characteristics. Was evaluated the systems using the best natural lighting conditions and saving energy with adequate illumination to the better environments characteristics.*

Keywords*: natural lighting, solar irradiation, energy efficiency*

1. INTRODUCTION

Daylight is important for conception of the visual environment and better utilization of daylight may reduce the need for artificial lighting and internal gains caused by solar energy and electric lighting. Daylight may cause problems with glare on workplaces. Solar shadings are often applied to control glare and to reduce solar gains in order to avoid over heating. One of the main forms of direct energy saving with respect to lighting refers to the use of natural light, and when it is not possible to incorporate the buildings, facilities or equipments that minimize energy consumption, or using the interaction of the two systems, Balocco and Calzolari (2008). According to the 2007 annual energy balance, about 42% of electric power consumption of the country is due to residential buildings, commercial and public, including use with home appliances and office equipment. Specialized consulting services can guide on the rationalization of energy use for lighting systems as well as thermal control systems.

A correct assessment of the needs of luminance in each area of a building is an important step towards saving energy with lighting. Often, small changes in positioning of luminaries can correct needs of luminous intensity. The choice of the type of luminaries and lamp type on the response of the spectrum of colors are factors of great influence on the economy and quality of lighting. There are factors that can design lighting systems that use less energy than conventional designs how the use day lighting strategies throughout the buildings how electric lighting design that adjust the power lights in response to changes in daylight levels to the use of the suitable light source for the workplace. The use of modern tube fluorescent and compact fluorescent lamps, using the principle of passing a discharge arc through a gas in a compact tube shaped fixture, is known to provide lighting very efficiently with excellent color quality available. Actually, modern direct-indirect luminaries are 85 to 90 percent efficient, as compared to the 60 to 70 percent efficiency of older styles.

The use of natural light is an economical means of lighting in most buildings, but it's require thermal isolation when the room is used to the complex tasks, and yet, the variation of natural light in the day, has caused a tendency to closing of gaps, especially in architecture trade. To project high efficiency system lighting you must know the characteristics of natural and artificial lighting to coupling them, extracting the best that can offer the building, with regard to lighting. However, using the maximum natural light in hot climates may involve unnecessary heating by sunlight through windows and compromise the building's heat balance, Persson, Roos and Wall (2006). Therefore, the use of glas surfaces control can increase the heat-lighting performance. The sunlight reflected in the vicinity is important information for the design of the building, Gratia and Herde (2007). Although the knowledge and understanding of the characteristics of the sky luminance pattern are needed for a optimization of the project and with the objective of minimizing the energy consumption for lighting in a building, Lambers, Dutra and Pereira (1997).

The daylight luminance on the workplace area can be considered as the resultant value of three short wave radiation fluxes: diffuse flux from the sky, direct flux from the sun and flux from inside and outside reflections. The main objectives of the case study were increasing lighting energy savings due to less artificial lighting system utilization, the corresponding daylight luminance levels at long indoor distances from the windows, and to improve the uniformity of luminance distribution and luminance gradient across the work-plane and at different inside levels and a comfortable and suitable lighting environment under variable sun and sky conditions throughout the year. The proposal of this case study is to reach a high-energy efficiency in a laboratory with thermal environment stability.

2.ARCHITECTURE AND INDOOR CONDITIONS

The project of energy efficiency was conducted in a building, which is a laboratory used for antennas and telecommunications equipment testing. The dimensions of the building are 17 meters long, 13 meters wide and five meters height. The project of energy efficiency was applied to two types of environments, a room that was used to setup configuration and equal size rooms, an office and a meting room (Figure 1).

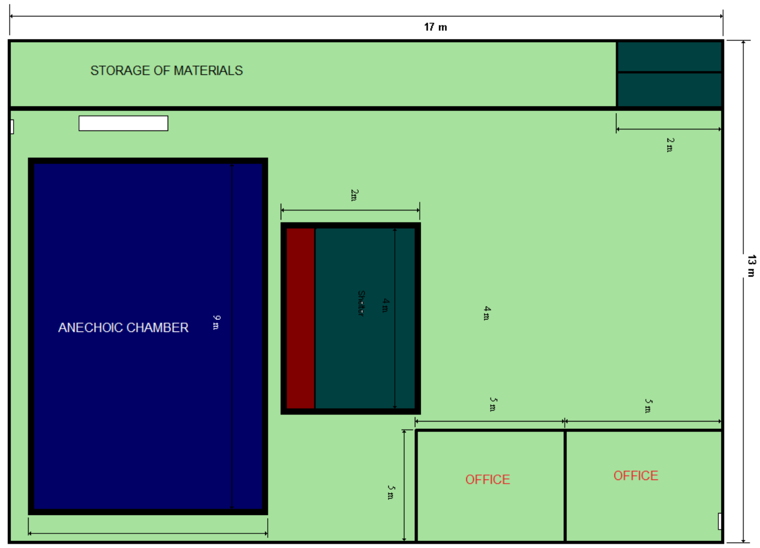

Figure 1.Indoor distributions rooms

The building is situated in a front-back line position with a hundred degrees azimuth. The sidewalls have windows beginning at the three meters height. The dimensions of the windows are 15 meters long and 1.5-meter height. Within the premises that the rooms are used for high-precision electronic instruments and these require special environmental thermal stability, such as the temperature must be controlled around 23 °C. The interference of heating changes when using natural lighting should be considered. Actually, the side windows were all painted with acrylic paint to completely prevent sunlight penetration.

The actual lighting of the rooms is artificial and the need for lighting must meet specific conditions of workplace. The main hall, with 104 square meters, is used for initial test setup with activities of mounting antennas and settings of angular position and equipment configuration. Will be considered the lighting of the two rooms with 25 square meters area, which are used as office and another for meeting room. In the main hall, a level of illumination in range of 500 to 800 lux is considered suitable. For meeting rooms and office tests, a level of illumination of 500 lux is considered adequate for the environment. The artificial lighting the current installation in each room consists of 6 luminaries with two tubular fluorescent lamps of 40 W each. The lamps are installed at the ceiling, at 2.4 meters height. The installed power is 480 W. In a visual assessment, there is a level of brightness above the needs of the room. In the main hall are fitted with 16 lamps of 110 W each. The height of the ceiling is 4.5 meters. The lamps are fixed near the ceiling. Was observed that the installation of lights inside the room is not enough for same special activities**.**

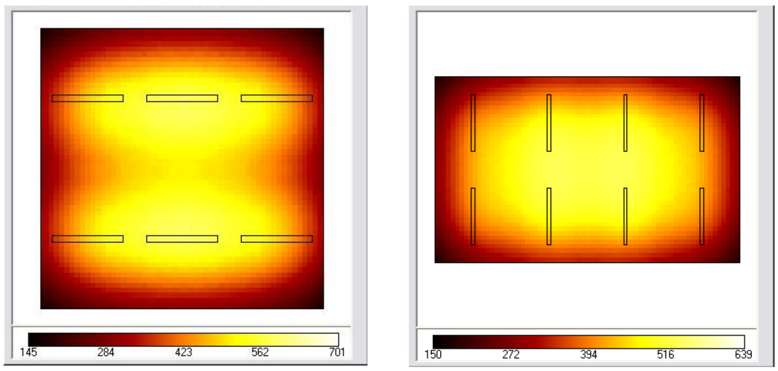

Figure 2.Current conditions of illuminating in the office 480 W and the work area 1780 W.

With the use of the resources software softlux of the company Itaim was possible to calculate the current conditions of artificial light and carry light with proposals for a reduction of consumption and improves better performance activities. The current conditions of illumination are showed in Figure 2.

It may be noted that the office rooms, mainly in the center, are points of excess light, and another points, corners of room, is lighting deficiency. The levels of brightness of the room are inadequate for the activity; less than 500 lux, and distribution of lamps favors the appearance of dark spots near the sidewalls.

3. DETERMINATION OF EFFICIENT ARTIFICIAL LIGHTING

In determining the best conditions of artificial light to get the best working conditions, were first considered the following conditions:

a) There was no need for changes in painting the walls and ceiling because the levels of light reflectance of the walls were considered ideal;

b) We verified the characteristics of the lamps and luminaries to provide a better condition for lumens per watt;

c) Were recorded the position, characteristics of reproduction of colors and number of luminaries. It was considered the height of the suspension of luminaries.

Several conditions, using the software company's Itaim softlux, were simulated to determine the best conditions for energy efficiency. In the office rooms, we observed that keeping the same type of luminaries and the replacement of lamps of 40 W to more efficient light bulbs of 32 W, it was possible to reduce the number of luminaries to obtain a better lighting distribution of the workplace surface. The distribution of light at 0.75 meters from ground level is illustrated in figure 3. The new distribution of lamps you can get an economy of 224 W per room.

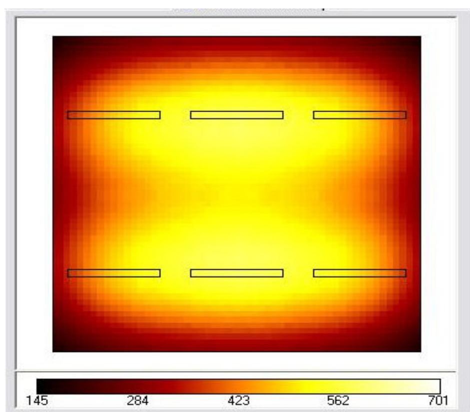

Figure 3.New distribution light in the office rooms.

In the main hall, the characteristics of luminaries and lamps were considered ideal for use in this workplace. However, as the lighting conditions were not suitable for the implementation of activities, was analyzed in the simulations, the number of luminaries and the height of suspension.

The initial modifications of the simulation was determined by increasing the number of lamps, as the installation of lights at a height of 4.5 meters of soil is a high attenuation of the light in the work plane, it will increase the consummation of the energy. The following simulations were performed with the variation of height of suspension of luminaries. The result of modifying the height of the suspension to 1.5 m down is illustrated in the Figure 4.

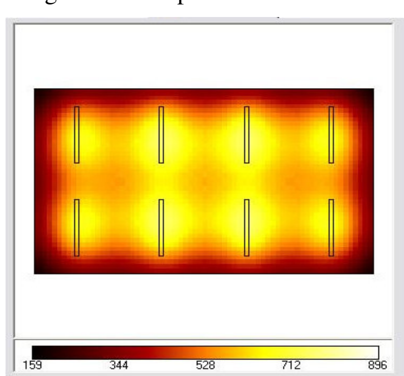

Figure 4.New lighting the hall off equipment preparation with luminaries down 1.5 m.

It was observed that there are points of high brightness dimmed, which can result in effects of shading of objects. Another way was to change the suspension to a height of meters equivalent to 3.5 meters of soil.

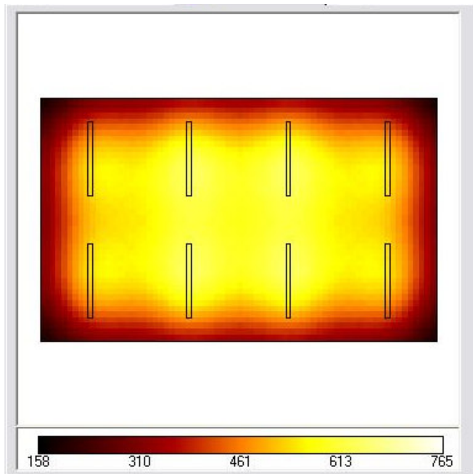

Figure 5.New lighting the hall off equipment preparation with luminaries down 1 m.

Observe that the distribution of light is more homogeneous (Figure 5) and in the point to close to the walls there are points dimmed, which means no problems with the activity. With this configuration the economy can achieve a power of 440 W.

It is as a result of changes in three rooms with a small investment of labor and replacement of 16 light bulbs, a power saving of 888 W.

3. NATURAL LIGHTING

Currently the building does not allow the use of natural light because the area of windows, totaling 45 square meters, is a cover of white acrylic paint, which completely prevents the passage of light radiation of the Sun. Was verified the conditions of irradiation in the region where the building is located. For simulation of total irradiation on the external areas, was used the software RADIASOL of Solar Energy Laboratory of the Federal University of Rio Grande do Sul. Which the simulation was possible quantify the level of solar radiation on the sidewalls and the irradiation in the windows.

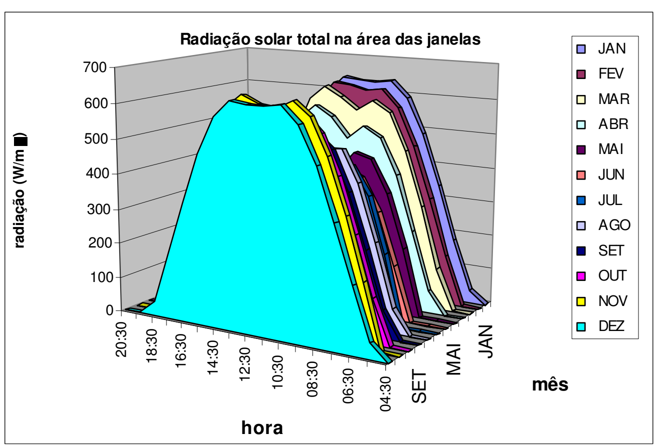

Figure 6. Solar radiation on the external windows area.

When examining the graph of Figure 6, you can check certain stability in the level of radiation during the activities of the laboratory. In the analysis of the values can be observed that in the worst case the sum of the levels of radiation that reaches the outer surface of the windows on both sides is greater than 400 W per square meter for a minimum of six hours. Actually, only the thermal component of radiation reaches the interior of the building.

The purpose of this study is to simulate conditions of natural light for as long as possible and assess the losses from the use of conditioners for cooling to maintain internal temperature in the suitable conditions. The first proposed task is cleaning the painting of glass. With the glass, the conditions of visual comfort may be adversely affected by incidence of direct solar radiation. Similarly, the cost to reduce the thermal load caused by the direct radiation can be greater than the energy saving with the use of natural lighting.

The use of filters, solar radiation on the surface of glass is a viable alternative, knowing that, it is necessary to verify the characteristics of the film on the mitigation of radiation and light attenuation for thermal radiation and maintain the visual comfort. Some types of movies with filter solar radiation and the level of transmission was analyzed (Table 1).

Table 1. Films characteristics.

Float	thickness	Relative transparency (%)			Total transparency (%)
		Ultra-V	Visible	Infra-V	(%)
Refletive gray	6mm	11	43	72	63
Refletive bronze	6mm	5	28	45	40
Refletive green	6mm	5	53	42	43
Laminate colorless	6mm	2	85	63	65

Was chosen for the simulation of the film with reflective bronze due to the low transmittance of the infrared spectrum. Were used in the calculations of the radiation beyond the windows, the values of transmittance of the film used and the attenuation of glass. The graphs of Figures 7 and 8 show the levels of light in the windows on the east and west.

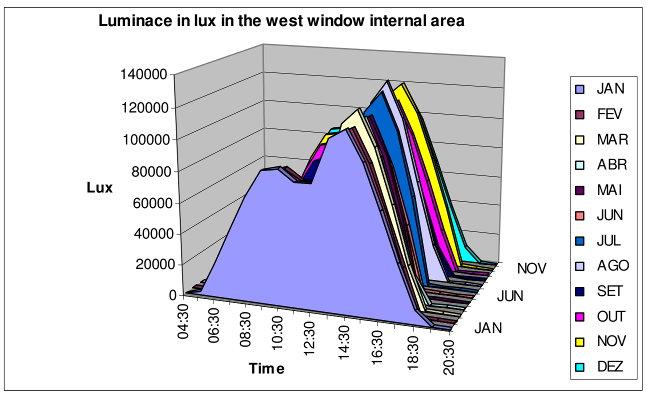

Figure 7.Luminance in the west window internal area

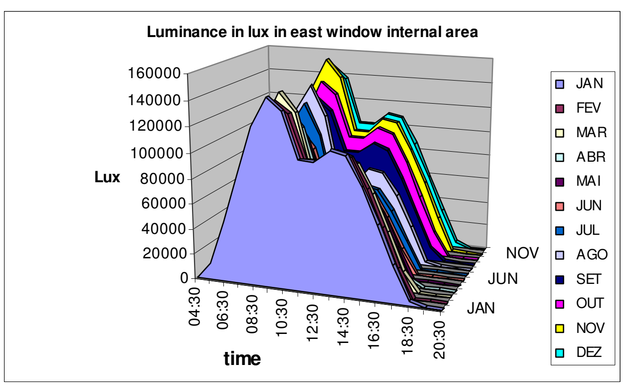

Figure 8.Luminance in the east window internal area

The levels of radiation passing through the window are dispersed in the form and amount of light that reaches the ground in the area near the window is approximately 10% of brightness in the interior of glass. O graph of Figure 9 shows the levels of brightness in areas close to the ground in the assembly hall for the trials. It can be observed that the conditions of illumination remain level during the work. In the calculations were averages of 60% of days with sunshine diffuse total. The Figure 10 shows the ratio of power spent on the additional thermal load and the power used with artificial lighting

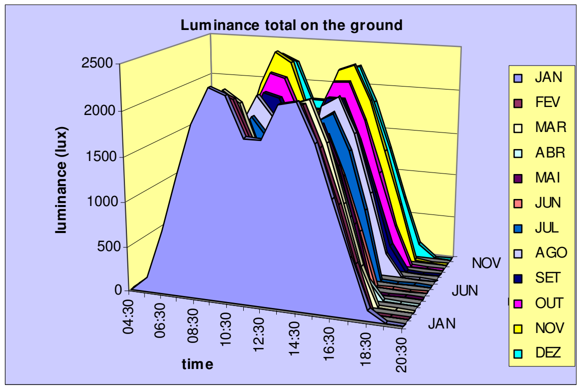

Figure 9.Brightness in areas close to the ground

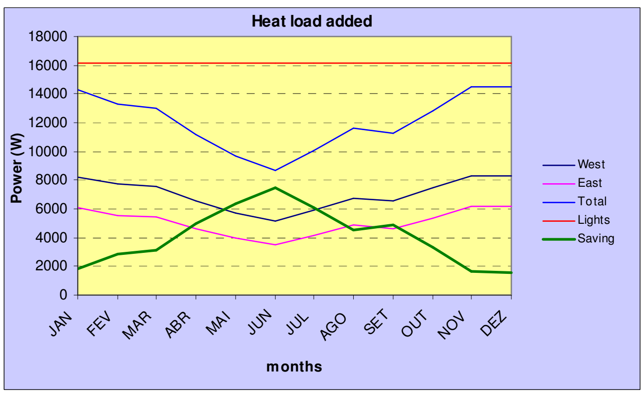

Figure 10.Heat load added and total energy saving

4 Comments and conclusions:

In evaluating the results showed that the area of the windows is enough for good lighting conditions. However, the added heat load in the enclosure can be a deterrent factor for a good condition for energy efficiency. Indices were adopted and conservative with respect to levels of luminance in the windows, for example, has adopted a percentage of sixty percent to the diffuse radiation corresponding to the days of clear sky or cloud cover of low density. Other tests can be performed using a smaller area of windows or replacing windows for blocking opaque film, which have a higher transmittance to light and consequently a reduced need for open windows. We conclude that the use of day lighting is feasible in older buildings and can also be applied in new architectural projects.

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