ENERGY USAGE REDUCTION STRATEGIES FOR A PUBLIC UNIVERSITY BUILDING

Abstract. *Rational use of energy is becoming more and more important nowadays. Among its several aspects is end use efficiency in buildings. The Brazilian main source of electrical energy is hydraulic and, due to increasing energy demand and delays in conclusion of old powerplants due to environmental concerns, the country recently experienced a shortage in electrical energy supply. The effective and proper use of energy is becoming more important, and efficient use of equipment, natural resources preservation and reduction and mitigation of environmental impacts must be accounted for.*

This paper proposes the analysis of the use of evaporative coolers in office rooms in a public university building as an alternative for reducing energy usage, demonstrating how some actions may be implemented and possible accruing results, focusing on sustainability of public buildings, at one of the largest public Universities in Latin America.

Keywords*: sustainability, evaporative cooler, air conditioning.*

1. INTRODUCTION

The University of São Paulo (USP) started, in 1997, a program to design and implement actions in order to reduce energy consumption, called PURE-USP (Permanent Program of Efficient Use of Energy) (Saidel *et al*., 2003; Hernandez, 2005). Among several implemented actions, an on-line measurement system for energy consumption that allows development of a database on building energy consumption profiles stands out, which has become a very important tool for planning retrofitting actions.

Since its beginning, several retrofits have been implemented in air conditioning systems in use at the University. Another goal of the PURE program is to evaluate alternative systems, in order to reduce total energy consumption. Among them, the evaporative cooler can be considered as an alternative for temperature control systems for office rooms.

2. Literature review

Masiero (2006) compared evaporative cooler equipment to a unitary air conditioning system installed in small construction cells. The experiments compared dry bulb temperatures and energy consumption for both systems and concluded that the evaporative cooler can be an alternative for control of thermal comfort conditions in a closed environment. The author tested the evaporative cooler in a very small environment without occupation.

Storf (2004) analyzed the use of an evaporative cooler in a classroom and its impact in the thermal comfort of its occupants. The author used a form with questions about thermal comfort, to be filled by the occupants. After statistical analysis of the filled forms, the author concluded performance of evaporative coolers is highly dependent on its positioning in the room. Besides, quality of water supply should be controlled in order to avoid problems with the classroom air quality.

Faria (2008) compared the use of evaporative coolers in office rooms in a public university to a solution deploying unitary air conditioning equipment. This comparison takes into account the air and dry bulb temperature profiles, in order to evaluate performance of such systems regarding these parameters. The results show that the evaporative cooler provides a good air dry bulb temperature and velocity distribution for office rooms, indicating that this system is a good solution to provide thermal comfort.

Hernandez & Fiorelli (2007) analyzes the use of simulation tools, as an energy consumption auditing and predicting tool is tested in a case study at the Administration Building of the University of São Paulo. The building energy usage profiles are collected, as well as the campus meteorological data. A parametric analysis for the simulated building models is run on Energy Plus, in order to evaluate the influence of several parameters, such as the building occupation profile.

3. Methodology

3.1. Building description

The analyzed building is the Mechanical Engineering Building at the Escola Politécnica of USP, that has a 22,540m^2 area and was built on 1965 (see Fig. 1). The building has a permanent population of 200 employees (teachers and administrative staff) and a variable population of 500 (mostly undergraduate and graduate students).

Figure 1. Aerial view of the Mechanical Engineering Building

The Program for Rational Use of Energy (PURE-USP) uses software in order to manage electrical energy demand of the University, which is called SISGEN and was developed by the Electrical Energy and Automation Department. It is possible to evaluate energy demand profiles for the Mechanical Engineering Building from SISGEN provided data (see Fig. 2 and 3). SISGEN can assess the following parameters: electrical energy demand (periodically assessed every 15 minutes), as well as daily and monthly energy usages. For the analyzed building, data provided by SISGEN for the period from September 2006 to September 2007 was used for the herein reported analysis.

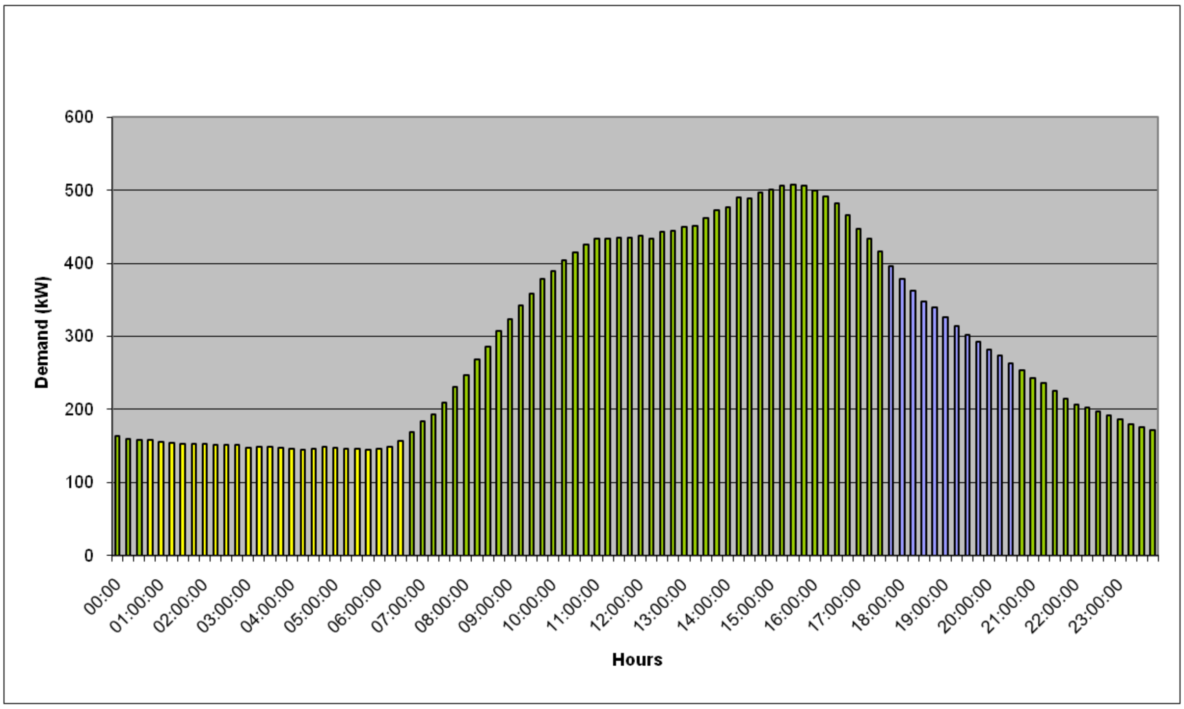

Figure 2. Energy demand profile for a typical week day

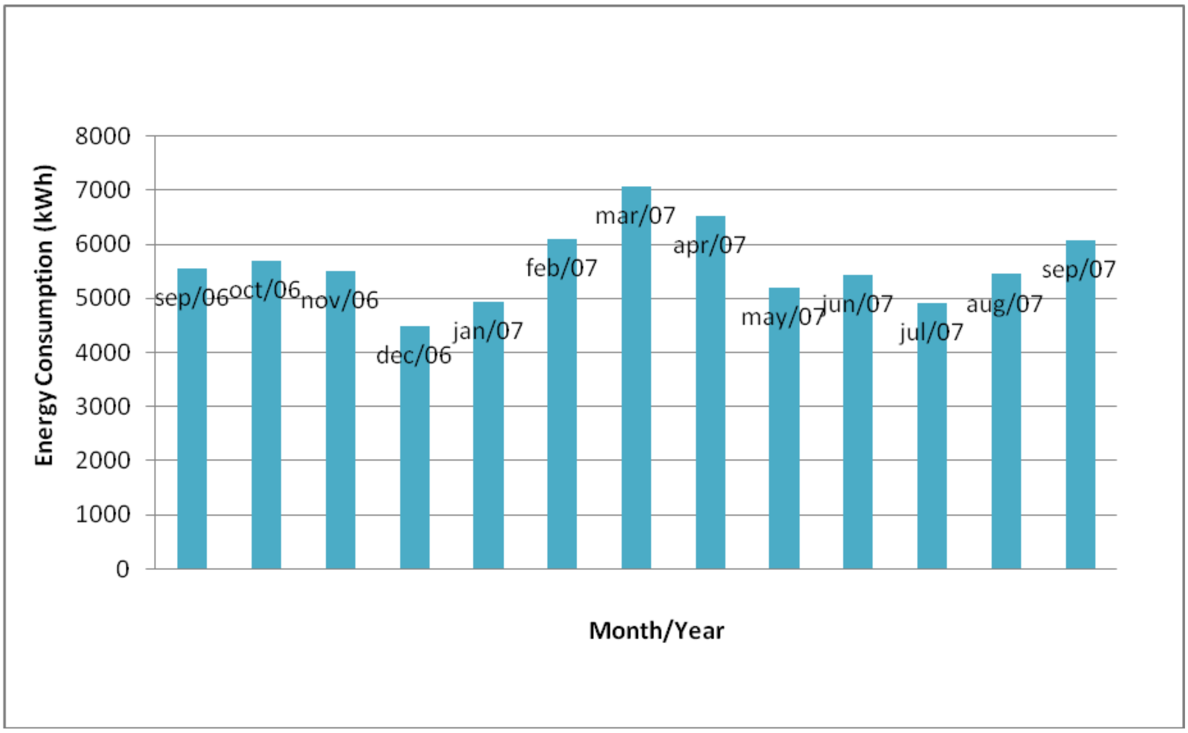

Figure 3. Monthly energy consumption profile for the analyzed period

A survey was performed assess division of the building into functional areas regarding, with the following classification arising from it:

- Class room
- Library
- Staff room
- Clusters
- Corridors and passages
- Laboratories
- Amphitheatre and lecture room
- Students Office
- Teacher rooms

The survey also evaluated the demand and consumption of electric energy for each area, based on their respective average use times (see Figs. 4 and 5).

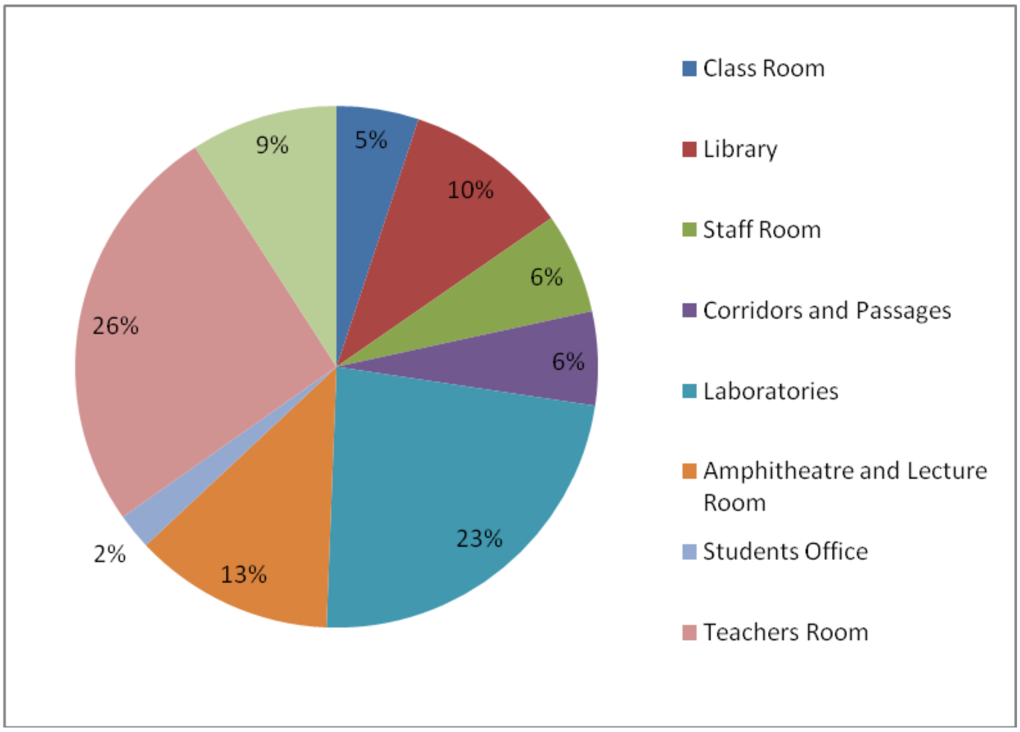

Figure 4. Distribution of energy demands for the Mechanical Engineering Department

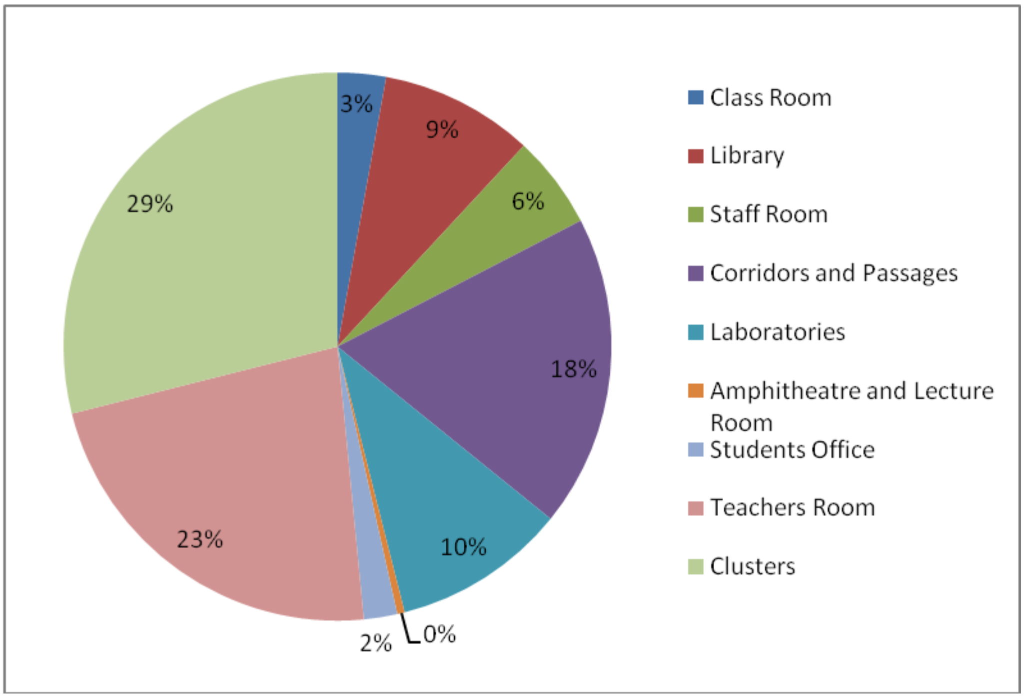

Figure 5. Distribution of energy consumptions for the Mechanical Engineering Department

Based on Figs 4 and 5, one may see that there are two areas with a good potential for actions on reducing energy usage: teacher rooms (23%) and the corridors and passages (18%). The laboratories and clusters have very little possibilities for retrofitting, for they are critical areas, where changes are more difficult to be done. Therefore, retrofits on these two areas will be assessed.

3.2. Corridors and passages retrofit

Distribution of energy usage by end uses is as follows: 45% for lighting and 56% for other equipments. Lighting systems may reduce their energy usage by replacing 40W lamps for 32W ones. This reduction is to reduce energy usage on corridors and passages by 24%, for a 4.3% reduction of total energy usage in this building and a R$ 1.12 reduction on the energy bill. Based on average prices for 32W fluorescent lamps, this retrofit action will have an extremely long simple payback period (more than 20 years). Therefore this retrofit action will not entail significant reduction of energy usage for this building.

3.3. Teacher rooms

In order to assess potential reduction of energy usage in this area, a detailed survey was done to assess distribution of end-uses. Results for this survey are displayed on Fig. 6, which represents a typical distribution energy usage in a teacher room energy consumption.

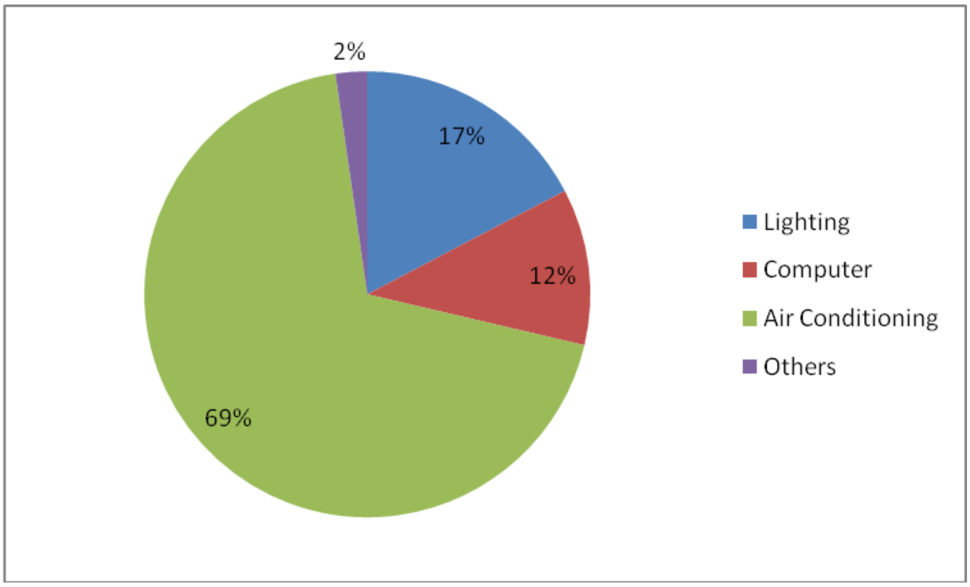

Figure 6. Typical distribution of energy usage among end-uses for a teacher room

As seen on Fig. 6, 69% of the energy usage is related to air conditioning; therefore an alternative system will be assessed for reducing energy usage in this area. The proposed alternative system is an evaporative cooler (Fig. 7), that for a standard teacher room has a typical energy consumption levels 90% below those for a unitary air conditioning appliance, which is the typical system used in teacher rooms.

Figure 7. Evaporative cooling appliance

From the reduction of energy usage accruing from using the evaporative cooling appliance and the end-use distribution of energy usage at the Mechanical Engineering Department, the average reduction on energy usage is assessed as totaling 21MWh/month, which means R$ 5,572.00/month savings, for total replacement of unitary air conditioning appliances by evaporative cooling ones. From depreciation values of unitary air conditioning appliances and purchase prices for evaporative cooling appliances, simple payback for this retrofit amounts to 23 months. Regarding the thermal comfort aspects, Storf (2004) evaluated that the evaporative cooler system can provide satisfactory conditions for the occupants of the room for 90% of a typical year in São Paulo based on the thermal comfort criteria developed by Fanger. Based on these criteria, it was evaluated that the evaporative cooler system provides satisfactory thermal comfort conditions for 80% of the occupants for established indoor ambient conditions.

4. Conclusions

This paper presents and demonstrates a methodology for assessment of energy saving potentials of retrofit actions, as applied to a case study at the Mechanical Engineering Department of the University of São Paulo. The paper analyses two retrofit actions: lighting power reduction on the corridors and passages and the replacement of window air conditioning for evaporative coolers appliance. The first one provides a very long simple payback period (more than 20 years) which may not be considered for implementation. For the second action, the results show that replacement of unitary air conditioning systems for evaporative coolers appliance represents a good opportunity for reduction of energy usage at this building. Further studies should be implemented in order to assess more retrofit actions for reduction of environmental impacts from such buildings.

6. Acknowledgements

The authors would like to acknowledge and thank PURE, for supporting this research by providing the electrical energy usage measuring system used along this project.

7. References

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7. LIABILITY NOTICE