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ScienceDirect

Energy Procedia 111 (2017) 101 – 110

Energy Procedia

8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11-13 September 2016, Turin, ITALY

Research of design features that influence energy consumption in office buildings in Belo Horizonte, Brazil

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Abstract

Buildings in Brazil in the residential, commercial and public sectors represent, according to the National Energy Balance in 2015, 50% of the total electricity consumption of the country. According to the National Energy Plan 2030, buildings energy consumption is projected to grow 3.7% per year by 2030. Thus, understanding of the architectural variables that influence the consumption of buildings has significant importance to contribute to the reduction of the expected energy demand for these buildings. The aim of this work is, therefore, the analysis of the architectural variables in the 102 office buildings of medium and large electricity consumption in the city of Belo Horizonte for which the monthly consumption per square meter was obtained. Then, the sample was segmented considering the following parameters: air conditioning system type, window-to-wall ratio, existence of glass facades, average absorptance of the walls, type of glass, existence of solar protection and construction decade. This segmentation was statistically treated using the frequency of occurrence of the listed building features and their influence on consumption of the sample was analyzed. The results indicate that naturally conditioned or mixed-mode air conditioned system buildings consume up to 58.7% less electricity per area in comparison with buildings with central conditioning systems in the city. This is explained by the fact that Belo Horizonte is a city with a mild climate with high percentage of comfort hours when natural ventilation is used. This discussion becomes important once it is believed that the analysis of such data can contribute to presenting guidelines to designers and legislative bodies to improve the building design decisions in order to achieve lower electricity consumption in buildings.

Peer-review under responsibility of KES International.

Keywords: energy consumption; benchmarking; building design

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Peer-review under responsibility of KES International.
doi:10.1016/j.egypro.2017.03.012

1. Introduction

According to the Energy Demand Study [1], the world population is estimated to increase from 6 billion people in 2000 to around 9 billion by the year 2050. This expected growth, in addition to the increase in power consumption of the population, impacts in a direct way the overall energy consumption framework, creating the need to consider alternatives able to reduce this growth impacts.

According to Perez-Lombard *et al* [2], in the commercial sector, office and retail buildings have the highest electricity consumption and CO_2 emissions. Office buildings in the US account for 18.0% of electricity consumption and 3.2% of total energy consumption. In Spain, the office buildings account for a third of the commercial building sector energy consumption and are responsible for the consumption of 2.7% of the total energy consumed in the country. In the UK commercial buildings consume 17.0% of electricity and 2.0% of total energy consumption. In Brazil the buildings in the commercial sectors and public services represent 14.5% of total electricity consumption in the country [3].

Therefore, in Brazil as in other countries, the construction, operation and use of the buildings mean a significant share of electricity available of the country and therefore represent a great potential for energy conservation. Thus, it is of fundamental importance to ensure that the quality of life offered by the building and its facilities are compatible with the minimum standards of habitability and consumption and besides, they are considered ways and means to implement energy conservation programs are considered [4].

Energy consumption in buildings is related to gains or heat gains or loss through the building envelope which, in addition to the internal loads generated by the occupation, the equipment use of equipment and by artificial lighting, result in the consumption of air conditioning systems, plus the own lighting equipment and systems [5].

The implementation of energy efficiency strategies in buildings not only reduces peak energy demand, but also reduces the use of energy in general and the impact that buildings have on the environment. A good architectural design should include analyses of their energy performance, as each decision taken during the design process can influence the thermal and light performance of the building [6]. The project interactions and decision-making must be set correctly allowing the array of architectural responses of the various problems to produce integrated results. Passive buildings, with low energy consumption, that have climate control strategies will provide a greater opportunity to adapt to climate change [7].

The various parameters that influence the building's consumption should be investigated and checked for the possibility of design change so that the building becomes more efficient. The architecture should assume the role of minimizing the climatic effects and not to intensify them or aggravate them [4,8]. Assess the energy efficiency of a building is a more difficult task than in equipment in general, because the efficiency covers an interplay of factors such as architecture and environmental variables like external temperature and humidity, systems, among others [9].

Studies of the impact on some architectural features such as the shape of the building [10,11], opening percentage in facades, colors and shading devices [12,13], showed that there was significant variation on total consumption and energy costs by altering constructive variables.

Climate characteristics may also influence the energy consumption in buildings and to minimize these influences, the architecture must be able to offer thermal conditions compatible with human thermal comfort inside it, regardless of external weather conditions. Thus, the architecture should assume the role of minimizing the climatic effects and not intensify them or aggravate them [4,8].

In countries where energy efficiency regulations already consolidated or in consolidation, an important parameter to be raised is the power consumption according to the typology of buildings. These surveys are called benchmarks, which are an important tool to promote the efficient use of energy in commercial buildings [14,15]. Having a large database created is the starting point to proposing new criteria for construction, for performing evaluation of existing criteria and improve the management of buildings of different performances.

When it comes to the Brazilian reality, according to the National Energy Plan 2030[16], the energy consumption of buildings is projected to grow 3.7% annually through 2030, which would represent an increase of 55.5% in electricity demand over the next 14 years. In this sector are the commercial buildings that consume 14.5%of the electricity in the country and several studies have significant potential to improve efficiency in energy consumption.

According to Dornelles [17], the most efficient mean for the designer to control the amount of heat that reaches