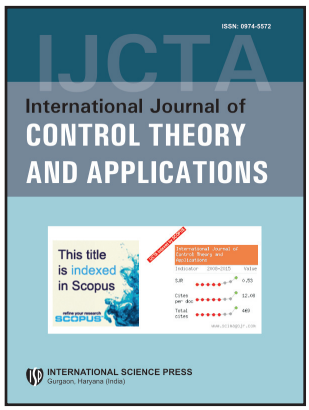

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Energy Efficiency Index of Ambulatories and Hospitals

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Abstract: The purpose of this study is to determine the energy efficiency index of 106 Ambulatories and Hospitals in the health sector, located in the city of Barquisimeto, State of Lara. To fulfill this purpose, the recommendations established in ISO 50.001 (2011) are used as references. Monthly electricity consumption records are obtained, which are analyzed to characterize the centers according to their consumption. Seven (7) representative samples of each category are taken and their annual electrical energy consumption and their number of beds are related. In total there are 7,632, registered between 2009 and 2014, both inclusive. An average index of 1117.07 kWh/bed is obtained and it is concluded that this index is highly dependent on the number of beds of the facility.

Keywords: Ambulatories, Health Centers, Energy Efficiency, Hospitals, Energy Efficiency Index.

1. INTRODUCTION

There are aggressive policies in the world to reduce the carbon footprint and increase energy efficiency. One of the policies is the proposal by the European Union called 20-20-20 [1], which means to reduce 20% of greenhouse gases (GHG), 20% of renewable energy and 20% increase in Energy efficiency by 2020. Similarly, other countries are investing heavily in raising awareness and creating regulations that encourage efficient energy management and the use of unconventional sources [2].

The enormous potential for energy efficiency improvements at all stages of energy production and use is widely recognized, but achieving this potential remains an almost global challenge [3], [4]. To this end, action plans are implemented that are linked to the different sectors, among them, and perhaps the one that has the most influence on the part of the state is the tertiary sector, which includes the health, commercial, educational and communications subsectors And public [5].

Energy dependence in the health sector, including outpatient clinics and hospitals, increases the need for reliable electrical installations, where not only is power supply continuous but also highly sensitive to variations

in voltages and currents. This means that, from the design stages, the facilities must safeguard the people, the equipment and the infrastructures.

Among the priority facilities of ambulatories and hospitals are: lighting, air conditioning, areas and vital support equipment, and security, among others. Each has special features and must be guaranteed that adequate power supply and ensure its efficiency.

In addition, energy resources are increasingly limited, so the efficient use of electric energy is a major issue. Hence the importance of implementing management systems that ensure a rational use of these resources and a decrease in consumption. Energy efficiency is evaluated according to the indicators, indices and targets established to ensure the proper implementation of actions to reduce the consumption of different types of energy qualifiers. Management systems help establish the mechanisms of evaluation and control of any type of organization. In this way, the rules that establish these management systems have been published. Within these standards, the recognized ISO 50.001 (2011) [6, 7] has been presented as an alternative that allows, with universal validity, to provide the infrastructures with a set of tools that facilitate their better energy performance. Understanding this performance such as energy use, energy efficiency and consumption of energy qualifiers. In addition, other standards for adequate energy management have been published, such as the IEEE 739 (1995) standards [8].

Based on the above, the objective of this study is to determine the Energy Efficiency Indices (IEE) of Ambulatories and Hospitals, under the guidelines established in ISO 50.001 [6,7]; With the goal of reducing energy consumption and leading to the reduction of GHG emissions and other related environmental impacts as well as energy costs.

In general, the IEE represents the relationship between energy consumption and production and allows to evaluate the correlation between these indicators of any institution, with a view to determining the effectiveness of the improvements implemented to reduce energy consumption without affecting the Productivity. Understanding effectiveness as “the ability to achieve the desired effect” [9]. In addition, it can be used for the comparison of consumption and savings measures implemented in similar sectors, the transfer of good practices and, finally, for the certification of processes.

The consumption index must be related to productivity that is to say, depending on the inputs, human and technological resources used and the products and services finally obtained [9]. For these variables can be used for the calculation and analysis of consumption, it is necessary, among other aspects, their statistical analysis that allows to determine the correlation between them and, in this way, to make an appropriate selection of the same ones.

2. ENERGY MANAGEMENT SYSTEM

The Energy Management System (SGE) allows the development and implementation of energy policies and establish objectives, targets, and action plans that consider legal requirements and information related to the significant use of energy. It also allows the organization to reach the commitments derived from its policy, to take actions, as necessary, to improve its energy performance and to demonstrate the compliance of the system with the requirements of this Standard. In this it applies to the activities under the control of the organization and the utilization can be adapted to the requirements, including the complexity of the system, the degree of documentation and the resources ISO 50.001 [6,7].

ISO 50.001 [6,7] is based on the continuous improvement cycle Plan - Do - Check - Act (PHVA) and incorporates energy management into the organization ‘s usual practices. The PHVA approach can be summarized as follows:

- Plan: conduct the energy review and establish the baseline, energy performance indicators (SDIs), objectives, targets and action plans needed to achieve results that will improve energy performance in accordance with policy Energy of the organization;
- Do: implement the energy management action plans;
- Verify: monitor and measure the processes and key characteristics of the operations that determine the energy performance in relation to the energy policies and objectives and report on the results;
- Acting: taking actions to continuously improve energy performance and the SGE.

3. METHODOLOGY

The difference between an Ambulatory and a Hospital is that the latter allows hospitalization stays for patients. These are classified according to the Number of Beds as shown in Table 1 [10].

ISO 50.001 [6, 7] considers that for an adequate energy management it is necessary to have indicators that show the performance of the qualifiers of each organization. It is necessary to measure and properly register the behavior of the same in order to verify the effectiveness of the measures implemented to reduce consumption. The purpose of the present study is to characterize the energy performance of ambulatories and hospitals, taking as reference 106 existing centers in the City of Barquisimeto, Lara, Venezuela, with a demand higher than 100 kVA, for the period from 2009 to 2014 [11].

Table 1
Classification of outpatient clinics/hospitals depending on the number of beds

Type of Outpatient/Hospital	*Number of Beds*
I	Between 20 and 60
II	Between 61 and 150
III	Between 151 to 300
III	Greater than 300

The methodology followed in the study consists in determining the correlation between the electric energy consumption of ambulatories and hospitals and relate them to the number of beds presented by each institution. The following steps were followed:

1. The monthly electric power consumption registry of the 106 outpatient clinics and hospitals was obtained for the period from 2009 to 2014, inclusive. That is, 7,632 monthly electricity consumption data were analyzed.
2. The different institutions were categorized according to their annual electricity consumption.
3. The consumption index (kWh/bed) is determined as the ratio between its energy consumption (kWh) and the number of beds, both for the same measurement period.
4. Correlation diagrams were performed by health center. In practice, by means of a statistical package, Pearson's correlation coefficient of the sample (r), or Pearson's correlation coefficient, is determined, which describes the intensity of the relationship between the two variables (in our case, Consumption of electric energy in kWh and water in m^3), and can take any value between −1.00 and +1.00. When it has a value of −1.00 or +1.00 indicates a perfect linear relationship, positive or negative respectively, between the dependent and independent variables, so that the forecasts would be perfectly reflective of reality. In contrast, if the Pearson coefficient r is close to 0, it indicates that the relationship between the variables is weak.

With data collected from 106 health centers, categories or classes were obtained through the use of the STATGRAFHIC® statistical package, in which 3 categories could be found, as shown in Figure 1.

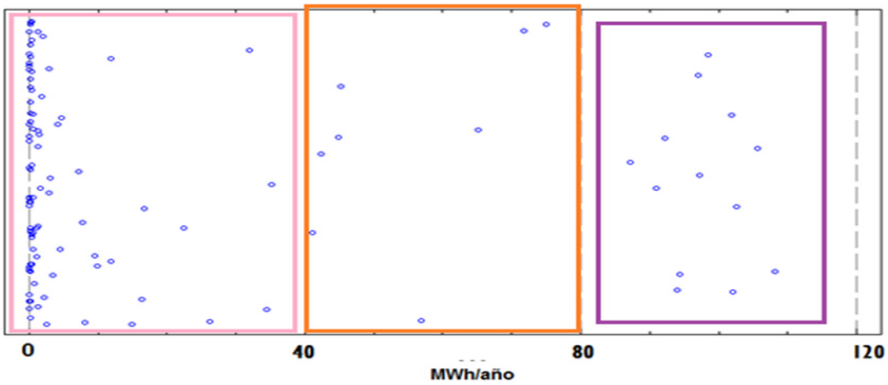

Figure 1: Scatter diagram of the annual electricity consumption of health centers

In Table 2 it is possible to observe the categories together with their limits of variability and their frequency of each one, in order to determine a summarized and ordered way as it varies according to a significant sample of the hospitals according to consumption.

Table 2
Classification of Hospitals according to the number of beds

Class	*Maximum Annual Energy Consumption (MWh)*	*Number of elements*
1	40.000	86
2	80.000	8
3	Greater than or equal to	12
	Total	106

Because in Category 1 it is found most of the data collected will be viewed in a more detailed way to see how they are distributed, similar to a subcategorization, in Figure 2.

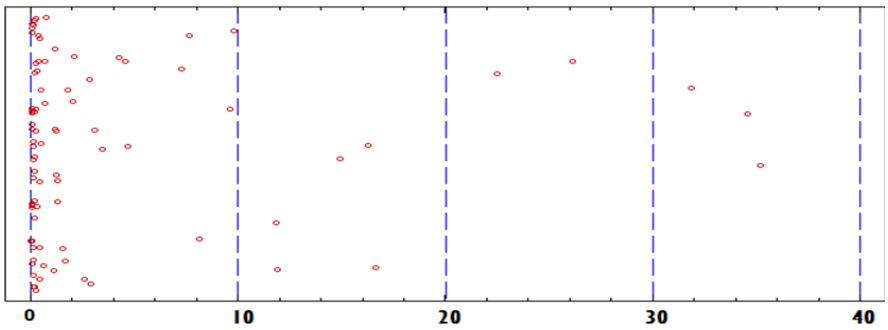

Figure 2: Scatter diagram of the annual electricity consumption of health centers in category 1

Table 2 shows the minimum number of representative of the set of health center elements and their calculation of the energy efficiency index according to the average annual energy consumption and the hospital / outpatient type, as established in [11].

Figure 3 shows the correlation between the annual electrical energy consumption and the number of beds, based on the seven (7) hospitalization centers studied, showing that R2 is greater than 0.75 and approaches 1, which detonates that both variables are correlated. The IEE average is 1,117.07 kWh / bed

Table 2
Classification of Hospitals according to the number of beds

Class	*Center*	*Consumption total (kWh)*	*Number of beds*	*Kind of center*	*Efficiency index (kWh / bed)*
1	Anticancer society	207.244	20	Hospital type I	10.362,20
1	Ambulatory Rafael Pereira	3.879	7	Outpatient clinic type I	554,14
2	Ambulatory of the Carucieña	271.297	40	Outpatient clinic type I	6.782,43
3	Hospital A.M.P	4.935.956	640	Hospital type IV	7.712,43
3	Military hospital	1.138.462	245	Hospital type III	4.646,78
3	Clinic IBD Barquisimeto	523.018	45	Hospital type I	11.622,62
3	Clinic Acosta Ortiz	739.680	36	Hospital type I	20.546,67

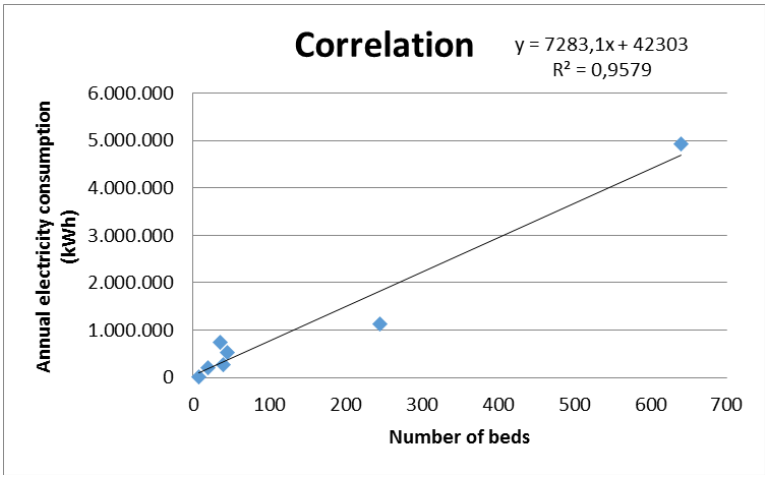

Figure 3: Correlation diagram

Within the health centers present in Table 2, two samples were taken (2) and based on an Energy Audit [11], [12], the percentage of energy consumption was obtained according to the given use, which is shown in Figure 4. The samples taken are the Carucieña outpatient clinic and the Acosta Ortiz clinic. It is shown that the main consumption is basically due to air conditioning (use of air conditioners), necessary to reduce the risk of contamination in operating theaters, followed by lighting and medical equipment.

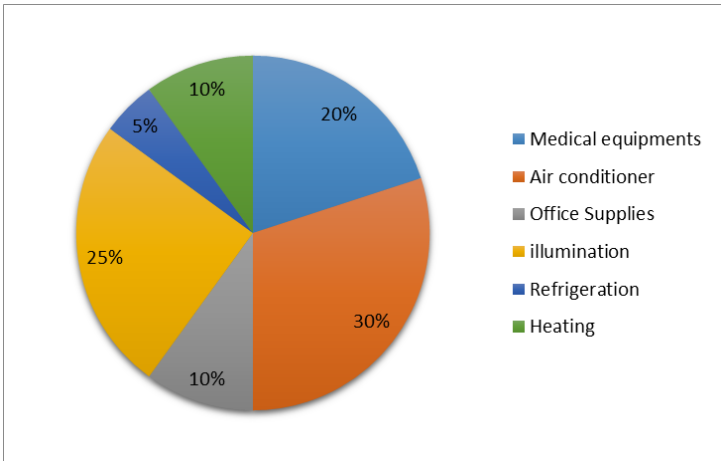

Figure 4: Consumption ratio

4. CONCLUSION

The results are a first reference that relates the monthly consumption of electric energy services provided by ambulatories and hospitals to ensure health, which brings as a benefit an important contribution to knowledge. According to the present study, the correlation between the consumption of electric energy and the number of beds 0.9579, for which the forecasts would be perfectly reflective of reality. It was established that for the 7,632 data analyzed for the period from 2009 to 2014 on average it was obtained that the IEE is 1,117.07 kWh / bed. The correlation graph shows that this index is highly dependent on the number of beds in the facility.

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