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Application of Equivalent Occupation Method as a Tool for Energy Management in Hotel Sector

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ABSTRACT

At nowadays, the operational control of energy performance indicators based on the equivalent occupation method plays a fundamental role in the rational use of energy for the hotel sector, since it allows in a competitive way to comply with the quality of the service offered by the company in terms of the thermal comfort of the occupants, minimizing the environmental impact. Within the framework of the energy diagnosis and implementation of the program of efficient energy management under ISO 50001: 2011, based on the method of equivalent occupation for a hotel company on the Colombian Caribbean coast, the line base, target line by 2015, determining performance control indicators such as accumulative trend and base efficiency index 100, to identify potential savings. From the diagnosis, 9.11% of energy savings were obtained by operational control. Through the implementation of corrective action plans, such as the shutdown of unnecessary equipment in the company, installation of LED lighting modules, the configuration of thermostats, in addition to training and sensitization to staff, and reactive energy control in the hotel effective savings were achieved around 8% of primary energy consumption by 2016.

Keywords: Energy Management, ISO 500001, Energy Performance Indicators
JEL Classifications: F64, Q40

1. INTRODUCTION

As a result of globalization and internationalization of markets and the integration of economies, it is necessary to review and rethink the fundamental mechanisms for the efficient operation of hotel companies within the framework of a global economy (Assaf and Vincent, 2012; Yang et al., 2017; Ashrafi et al., 2013). This efficient operation is part of the management of human, economic and energy resources (Bodach et al., 2016). The efficient use of energy allows maximizing the benefits (Pinto et al., 2017) and improving the competitiveness of any industry (Thumann and Younger, 2015) in a specific case the energy management in the buildings destined to the hotels have own characteristics in their methodology (Vujošević and Aleksandra, 2017; Malys et al., 2016), since they are installations of permanent use of refrigeration in order to guarantee comfort and quality for the guests in all their services (Sucic et al., 2015; Aguiar, 2005), this comfort implies the high demand for energy and fuel consumption of heating (Yun and Kim, 2014), ventilation and air conditioning systems, having as an impact the direct cost in the different (Kresteniti, 2017; Yao et al., 2015) operations of the hotel and building (AlFaris et al., 2017) without leaving aside the impact on the environment according to the International Energy Agency (IEA) show that approximately 40% of CO_2 emissions, including combustion processes and the generatin of heat and electricity, are related to industrial processes and comfort due to high energy use (Sucic et al., 2015; ASHRAE, 1997). As a result, the rational use of energy plays an essential role in saving this being one of the most promising tools for reducing energy consumption, energy costs (Fahad et al., 2017), from there the idea of the implementation of Energy Management Systems becomes an orientation for the different sectors of the economy to use energy resources in the best way (Valencia et al., 2017; Meschede et al., 2017), allowing the competitiveness in the industrial sector hotel, at the same time with facts such as environmental sustainability and eco-efficiency industry (May et al., 2015).

Currently energy efficiency in the hotel sector has become a challenge because the type of technology is the most influential in energy consumption (Fleiter et al., 2012; Deb et al., 2017), for example in India energy saving potential studies are conducted through the Energy Conservation Construction Code and anticipated energy efficiency measures in hotel buildings in Jaipur City, where it was found that expected energy efficiency measures save 50.29% energy in four star hotels, (Chedwal et al., 2015) another country that has studied this sector corresponds to Island of Gozo in the center of the Mediterranean where they give priority to the energy efficiency measures to achieve a zero energy hotel on the island of Gozo (Gonzalez and Charles, 2015), Italy for its part models energy consumption and efficiency measures in the hotel sector where it is shown that it is possible to achieve primary energy savings of 1.6 TWh (13%) by 2030 by (Pinto et al., 2017) implementing financially sustainable energy efficiency measures (Bianco et al., 2017), South Africa is also the energetic consumptions in its hotels or by means of sectoral comparative analysis of energy (Idahosa et al., 2017), Nigeria for its assesses the energy consumption and the carbon footprint of the hotel sector in Lagos (Oluseyi et al., 2016), where it is discovered that the significant correlation between energy consumption and total floor area, the number of guest rooms, the number of guest rooms equivalent and the number of employees. In general, different countries of the world contribute to the research of energy efficiency in hotels in order to achieve the reduction of energy consumption.

The United States in its extensive studies show the total energy consumption Other three organizations, ExxonMobil, BP and IEA (Anon, 2016), provide projections of energy consumption by sector. IHSGI (Global Insight) provides a forecast of the total consumption of primary energy (but not consumption by sector) and projections of sales of electricity, oil, and natural gas demand by end-use sector. To allow comparisons with the projections of BP and IEA, AEO2016 (Annual Energy Outlook 2016). Reference case the projections for the residential sectors and Hoteliers have combined to produce a projection of the sector of the buildings as shown in Figure 1.

Total energy consumption is higher in all years of the IHSGI projection than in the AEO2016 Reference case. IHSGI projects significantly higher total electricity sales than in the AEO2016 Reference case, which helps to explain much of the difference in overall energy consumption between the two projections as shown in Figure 2.

The use of unspecified CO_2 emissions regulations instead of the CPP in the ExxonMobil projections results in a different path for energy use and lower total energy use in 2040 in the electric power sector than in the other projections. Both the AEO2016 Reference case and ExxonMobil projections show residential energy consumption slightly lower in 2040, commercial consumption growing slowly, and transportation consumption lower in 2040. Industrial consumption increases through 2040 in the AEO2016 Reference case, while ExxonMobil shows industrial consumption declining from 2030 to 40. The direction of the trends is relatively consistent, if not the timing, even with deferent assumptions for the timing of environmental regulations.

Figure 1: Comparisons of energy consumption projections by sector, 2016, 2020, 2030, 2035, and 2040 (quadrillion Btu) (Anon, 2016)

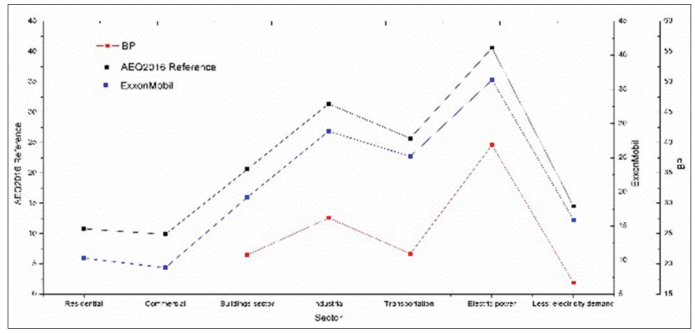


Figure 2: Projected energy consumption to 2040

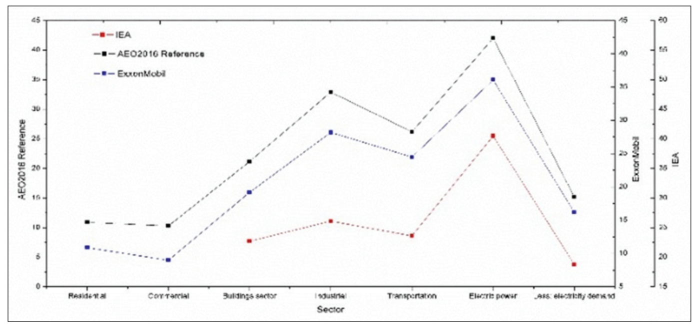
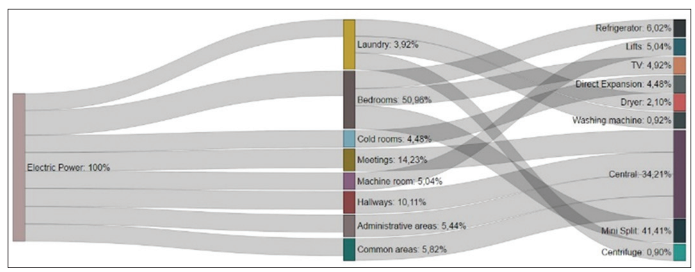


Figure 3: Hotel specific percentage energy matrix



In general, several countries have studied in different ways the energy consumption in various sectors of the economy for energy saving measures in their country, In this work the equivalent production application is used to obtain energy performance indicators in the hotel sector (Escorcia et al., 2017), with the purpose of reducing energy consumption following the stages of strategic decisions and energy characterization, which are fundamental for the correct implementation and Energy management (Tang et al., 2017). This paper presents the results of an energy diagnosis through the evaluation of energy indicators based on historical information on energy consumption and productivity, identifying opportunities for organizational, energy and technological improvements in order to direct the management department of the company to carry out the effective implementation of a Management energy system.

2. METHODOLOGY

In order to perform the hotel's energy description, in this section is presented, in a detailed way, the productive energy diagram and the energy matrix, in addition to the theory fundaments of the equivalent occupation method used for the calculation of the energy performance's indicators and the potential of saving.

2.1. Hotel Energy Description

2.1.1. Productive energy diagram

According to the data provided by hotel's maintenance department, the most significant primary energy sources are derived from electrical energy, as shown in the following figure where the energy-productive matrix for the hotel areas it's presented.

From the total electrical energy consumed, the most consumer equipment is those that are related to air conditioning, as the Mini Splits and Centrals which correspond to 75.62% as shown in Figure 3 from the total consumer devices.

2.1.2. Energy matrix

Figure 4 shows the energy consumption matrix for an annual period of the hotel, from this matrix it can be mentioned that more than 50% of energy used is electric energy, which indicates that the opportunities for rational use of energy must be focused on the savings opportunities in equipment and spaces where this energy is used. The values for the productive energy matrix and the energy matrix are presented in an equivalent unit of TCal (Tera Calories).

2.2. Energy Performance Indicators

The base efficiency index 100 is an energy management tool that allows the evaluation of the behavior of the energy consumption results measured over a period of operating time of the plant concerning the theoretical values of energy consumption calculated by the baseline. The base efficiency index 100 is calculated by equation (1).

$$Base\ efficiency\ index 100 = \frac{E_{theoretical}}{E_{Real}} \times 100\% \qquad (1)$$

This indicator generates alerts regarding positives and negatives variation in the energy efficiency of the process, thus facilitating the analysis and proposal of action plans in function of energy improvements, allowing the analytical interaction between production and energy consumption, aiming at a better energy performance of the processes of INDEGA's plant.

The energy consumption index is defined as the ratio between the energy consumed and the value of production obtained by this energy consumed as shown in equation (2), this is a performance indicator that is analyzed by comparing the real consumption index with the theoretical consumption index, both plotted against the plant's production. The real consumption index is constructed by using energy consumption and actual production data as shown in equation (3).

$$IC_{Real} = \frac{E_{Real}}{P} \qquad (2)$$

While the theoretical consumption index is constructed by equation (3)

$$IC_{theoretical} = \frac{E_{theoretical}}{P} \qquad (3)$$

2.3. Savings Potential

The savings potential not associated with the production of the Hotel Barranquilla Plaza is identified from the baseline, and target line equations, the consumption not associated with the production (ENAP) of the baseline and the target line is taken, so the savings potential is calculated according to:

$$Savings\ Potential = \frac{ENAP_{Base} - ENAP_{Target}}{ENAP_{Base}} \times 100 \qquad (4)$$

It is possible to determine a potential energy consumption saving associated with production, real and theoretical consumption index allows to establish this saving percentage associated with a production planning.

$$Savings\ Potential\ HBP = P_{Prom}\ (IC_{Prom} - IC_{Crit}) \qquad (5)$$

From the previous equation, ICProm is the average consumption Index of the real consumption indexes, calculated with the data of real consumption and production, while the ICcrit is the theoretical consumption index calculated for the PCcrit.

3. RESULTS

The energy characterization tools allow us to relate mathematically the historical data of energy consumption and production of the company, using a linear relationship (Figure 5).

3.1. Control Limits Plots

The control limit plots set an upper limit and a lower limit as shown in Figure 6, separated three times the standard deviation of the average data supplied as shown in equation (1) and (2).

On the other hand, Figure 7 shows the graph of control limit for the production data, given in the study time.

From the above graphs, we can see that the consumption variable is within the control limits, as is the production variable. There are no behaviors that indicate that these variables are out of control.

3.2. Pareto Chart

The hotel concentrates its attention on the consumption of electrical energy, so it will study the energy consumption by each type of equipment in the hotel and also the consumption by areas, identifying 20% of the equipment and areas that generate 80% of total consumption in 2015 using the Pareto Chart shown in Figure 8.

The hotel has a total of 206 mini split, 70 centrals, and 176 mini-bar coolers, which are the equipment that shows a significant energy consumption above 80% of the total. Therefore, attention is focused on the operation of this equipments, so that, if the reduction in the consumption of this equipment is achieved, it will be reflected in a significant decrease in the consumption of electric energy.

The rooms and lounges are the places of the hotel that show greater energy consumption which will be the center of attention for the

Figure 4: Hotel productive energy matrix

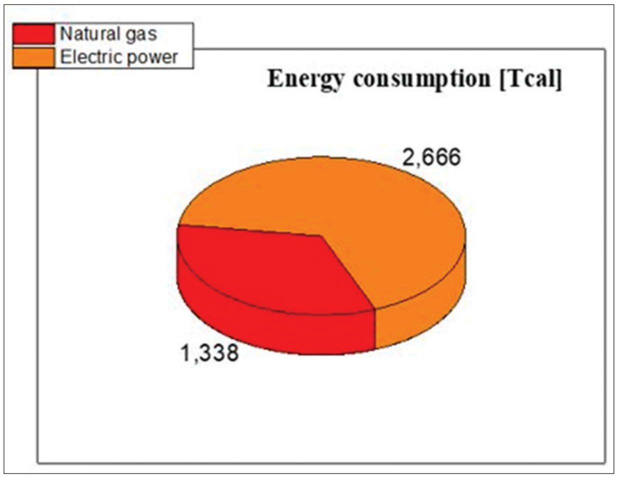


Figure 5: Energy and production demand E-P versus T

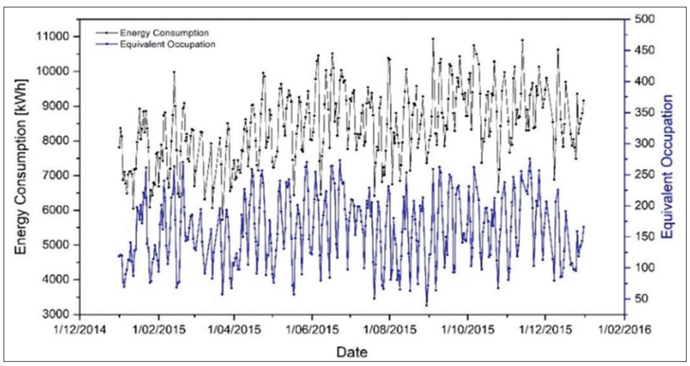
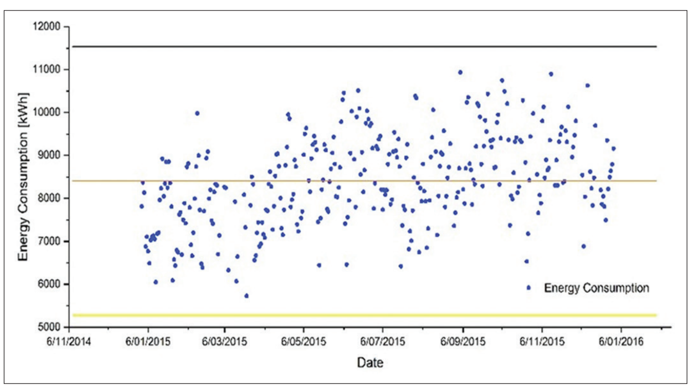


Figure 6: Control limit for electrical consumption in LGC 1



analysis of possible opportunities for improvement since the equipment of greater consumption shown in the previous diagram are located in these areas.

3.3. Graphic - Energy Versus Production

Once obtained the values of energy not associated with production, we proceed to propose some goals of reduction of energy consumption, which in turn is money saving.

Figure 9 shows the new trend line, which is below the previous trend line. Taking into account the new correlation of the data is 80%, is higher than that of the adjusted graph, which indicates that in addition to keeping the data relation, this relation is more significant, which shows that this correlation describes well the

Figure 7: Control limit for the production data

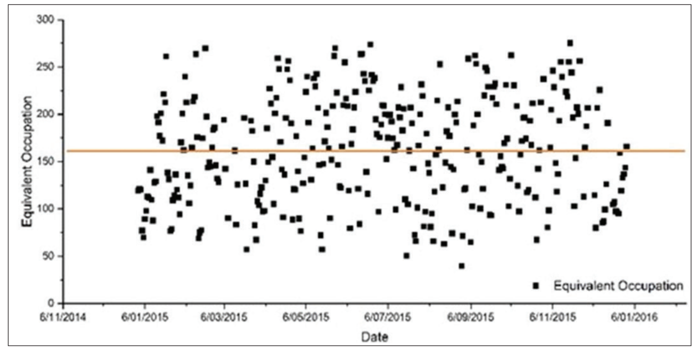


Figure 8: Pareto char

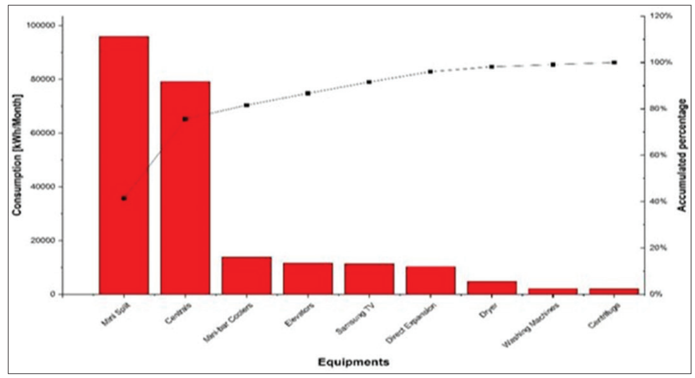
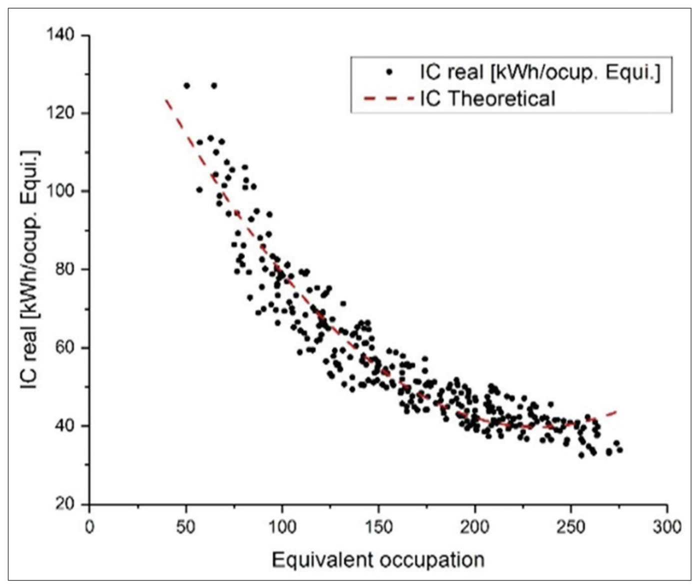


Figure 9: Target line graph



behavior of variables. There is also a reduction of energy not associated with the production of 9%. The task below is to take the appropriate measures and follow up on these measures in order to obtain these changes in energy consumption (Figure 10).

From Figure 11, it is observed that the consumption index varies between 36 and 182 (KWh/Ocu.Equi.). There are several levels of production below the critical point, which is at the point where the curve begins to rise. These productions are inefficient and increase the consumption index since it increases the relative weight of the energy not associated with the production in the real consumption.

The base efficiency index 100 can express two result ranges B100 <100% and B100 ≥100%. When the index is >100% it translates into a good energy performance since the actual electrical consumption was smaller than the expected electrical consumption, therefore in the points above the limit line, they are considered data of good performance located in the area of energy efficiency of the plant.

4. CONCLUSIONS

Based on the results obtained in the energy review stage in the implementation framework of an energy management system at Hotel Barranquilla Plaza, and according to the guidelines of ISO 50.001, is necessary to work on the significant energy uses of the hotel, to give continuity to the implementation stage of the system, since the estimation of the equivalent occupation for the hotel is very clear and identified, there are previous work and action plans already implemented. However, there is little infrastructure for the monitoring and control of energy indicators, there is no computing platform for verifying the functioning of the management system, which does not allow a continuous study of the Technological Improvements of zero or low investment to be carried out in the hotel that impacts on the consumption of energy and gas.

Savings opportunities without technological change have been quantified in the order of 9.11% of the monthly electricity consumption, which translates into 562.1 kWh equivalent to MM $ 81 per year, which can be converted into effective savings to the extent to guarantee the improvement of energy use and the sustainability of the reduction of energy costs in the company with low investment measures, starting from the development of a Monitoring Software, Measurement and Analysis of the energy performance for each USE installed and set up in operation at the hotel. Additionally, is identified that important efforts have been made by the hotel to pursue energy savings, but since no records or monitoring are kept, the results are not quantified, nor is the impact on the savings obtained with the implementation of the technological improvements of medium and high investment, that have been made in the hotel.

Finally, given the strength of the hotel in terms of its quality system in each of its processes, it is recommended to document the SGE and incorporate it into the company's management system, in addition to performing the internal audit exercise and later external of an Energy Management System, following the guidelines of ISO 50,001 for certification purposes.

Figure 10: Consumption index versus production

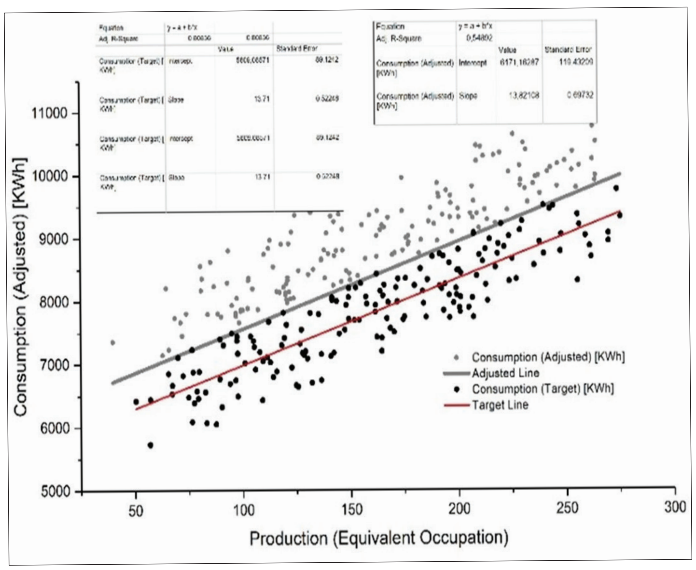
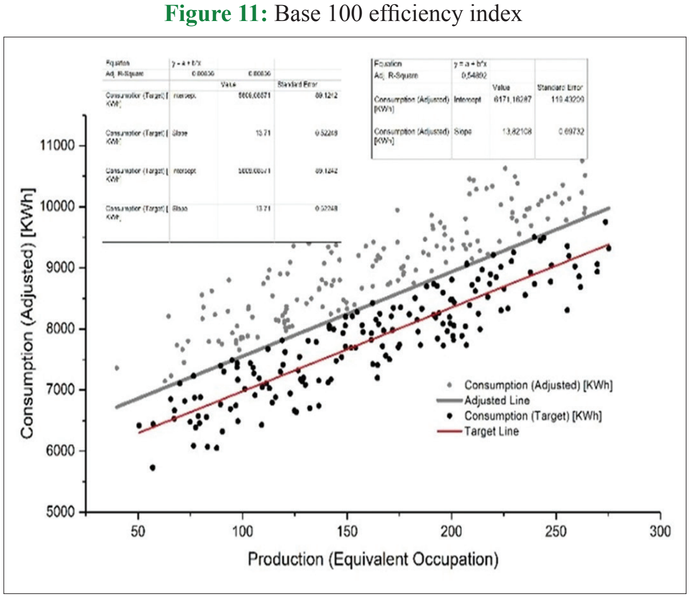


Figure 11: Base 100 efficiency index



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