EXERGY ANALYSIS FOR HOTELS IN THE DOMINICAN REPUBLIC: CURRENT SITUATION

Cynthia González*, Francisco Muñoz**, Jaume Roset***
Grup: Representació Gràfica de l'Exergia (RGEx)
Av. Diagonal, 649
08028- Barcelona, Spain
Phone: +34 93 401 63 80
http://rgex.blogspot.com
E-mail: cynthia.margarita.gonzalez@estudiant.upc.edu,*
*francisco.munoz@upc.edu***
*roset@fa.upc.edu****

Abstract

The need to investigate and improve the current model of energy use is essential, especially in industry sectors that consume the most. One of these industries is tourism, and energy consumption will vary according to their needs, uses and location. Conduct an assessment of energy and exergy used in hotels, comparing two different types of accommodation facilities, is a good start to determine the current status and consumption, and can help in the future to determine whether there are better solutions to achieve energy savings and energy efficiency of facilities. Room air conditioning is one of the largest energy consumption of a hotel, so special attention must be paid to the facility´s location as well as its orientation and architectural solution. The aim of this paper is to analyze and compare the energy consumption and comfort conditions of two hotels in Samaná, the northwest of the Dominican Republic.

Introduction

Tourism it´s a changing sector that moves around tourists preferences, tastes and habits; it has a strong impact in the built environment and architecture. Nowadays tourism is one of the biggest industries in the world and it´s a positive element in society. However, due to their operational characteristics hotels present a high range on energy consumption [1]. The hotel industry is one of the largest sectors of tourism industry and emits up to 21% of CO2 emissions from this industry and it´s estimated that contributes up to 5% of these emissions globally [2].

For these reasons it is necessary to contribute in searching for a more sustainable and efficient touristic model, that integrates the environment, not only in means of a nice landscape, but is relevant in the design, construction and wise use of a hotel. One of the objectives to be achieved in a short period of time is to obtain optimum energy efficiency, consuming less energy, but providing the same services. Savings and sustainability actions are needed in the Caribbean tourism-based communities, promoting good energy practices and responsible tourism.

In January 2011 two hotels have been visited Samaná, Dominican Republic. The information and measurements were taken on two types of hotel, the first in the Hotel Gran Bahia Principe Cayacoa of 5 stars, and the La Tambora Beach Resort 3-star.

Data on electricity consumption, water and hydrocarbons and the description of the facilities we have been provided by maintenance personnel in charge of the premises by meter readings, invoices and purchases that were carried out at hotels in 2010. Data regarding the monthly and annual average temperatures have been taken from the the Dominican Republic´s ONEM (Bureau of Meteorology). In addition, we have taken measurements outdoor and indoor temperature, as well as surface measurements and construction systems description.

Hotel Descriptions

Gran Bahía Principe Cayacoa

This hotel consists of 295 rooms, 72 Club Golden Junior Suite of 39m^2, 18 Superior Junior Suites of 38m^2, 73 Standard rooms overlooking the sea with 28m^2 and 132 Standard rooms with 28 m^2. Moreover, it is buffet style restaurant with 1, 3 theme restaurants, 3 bars, 2 snack bars and 1 disco.

A Standard room type was studied containing:

- 2 full size beds (1.35 m x 2 m) or 1 King Size (2 m x 2 m)
- Hydromassage cabins
- Air conditioning
- Satellite TV
- Ceiling Fan
- Coffee
- Equipped bathroom, hair dryer, magnifying mirror
- Also: Telephone, Safe, Mini-bar, Balcony / Terrace

Fig. 1: *Standard Room, Cayacoa Hotel [1].*

Cooling system

There is a chiller tower (cooler) with ice water to refrigerate the whole facility. Each room has a handler of 1.906.200 J (1800 BTU). It starts up automatically when the room system (room electricity) it’s activated inserting the room key in a card holder. This unit is also manually handled in terms of powering on/off, air speed and temperature; it stops automatically when the balcony door is opened.

Measurements

Cayacoa Hotel Annual Data					
Month	**% Occupancy**	**Electricity (kWh)***	**Water (m³)**	**Gas (l)**	**Diesel (l)**
January	97	410.506	17.818	33.955	2.037
February	97	398.817	16.992	26.839	2.184
March	81	418.420	16.277	23.924	2.275
April	77	385.768	16.504	25.703	5.739
May	55	373.140	15.870	26.593	3.672
June	82	450.405	18.301	27.936	2.377
July	82	478.482	23.867	29.867	4.349
August	82	465.021	19.058	31.192	2.472
September	84	434.693	16.337	33.111	4.225
October	73	445.819	17.227	30.738	2.896
November	88	393.544	19.031	30.094	4.948
December	55	370.345	16.228	26.990	2.226
Total	**79**	**5.024.960**	**213.510**	**346.941**	**39.399**

Table 1: *Average annual consumption Cayacoca Hotel.*

Interior temperatures ºC		
Hour	ºC	% RH
13:00	28	58,0

Table 2: *Interior Temperature*

Exterior temperatures ºC		
Hour	ºC	% RH
13:00	28	59,7

Table 3: *Exterior Temperature*

La Tambora Beach Resort

This facility is close to the beach surrounded tropical vegetation and gardens, it´s a 30,000 m² facility. The resort features colonial buildings connected by stone sidewalks that leads to three swimming pools, a Jacuzzi, a restaurant, and the beach. In addition, it counts with a shopping mall. It has 60 rooms divided in several Villas of 4, 6 and 8 apartments. A standard room (apartment) contains:

- 1 King Size (2 m x 2 m)
- Bathroom
- Air conditioning
- Satellite TV
- Ceiling Fan
- Safe
- Refrigerator
- Balcony / Terrace

* We use kWh unit because it is a unit commonly used in architecture.

Fig. 2: *Standard Room, La Tambora Hotel [2].*

Cooling system

There is an individual air conditioning unit for each room. It has an exterior compressor of 1.906.200 J (1800 BTU) and a inside unit. It starts up or off manually.

Measurements

La Tambora Hotel Annual Data					
Month	**% Occupancy**	**Electricity (kWh)**	**Water (m³)**	**Gas (gl)**	**Diesel (gl)**
January	97	12.480	48	6.791	407
February	92	12.000	50	5.368	437
March	95	13.560	50	4.758	455
April	93	14.520	49	5.141	1.148
May	73	14.520	48,5	5.319	734
June	80	9.960	52	5.587	475
July	38	12.360	55	5.973	870
August	30	15.120	53	6.238	494
September	33	18.360	49	6.622	845
October	25	15.480	50	6.148	579
November	33	14.400	53	6.019	990
December	95	20.400	47	5.398	445
Total	**65**	**173.160**	**604,5**	**69.388**	**7.880**

Table 4: *Average annual consumption La Tambora Hotel*

Interior temperatures ºC		
Hour	ºC	% RH
13:00	27	61,8

Table 5: *Interior Temperature*

Exterior temperatures ºC		
Hour	ºC	% RH
13:00	27	61,2

Table 6: *Exterior Temperature*

Data processing

Services Descriptions in Dominican Republic

Electricity
In the Dominican Republic there are 3 power distribution companies, 2 companies of generation through fossil fuels and 4 hydroelectric generating stations, as well as independent producers. The technologies used for electricity generation are: Steam Turbines (18%), Gas Turbines (16%), Combined Cycle Engines (23%), Fuel Oil (25%), Diesel Engines (3%), Hydro (14%). These are coordinated by the Dominican Corporation of State Electrical Companies (CDEEE). It is noteworthy that due to interrupted power supply utilities, citizenship uses alternative means of generation. The touristic industry uses gasoline-powered electrical generators. This increases the overall fuel consumption [3].

Water
Water resources are managed by the National Institute of Water Resources (INDRHI) and the Ministry of Environment and Natural Resources. The Dominican Republic has some surface water resources of 20,000 million m3 (BCM) per year, of which 12 BCM is groundwater recharge. However, the irregular spatial and seasonal distribution, coupled with high consumption in irrigation and urban water supply, resulting in water scarcity [4].

Hydrocarbons
The import, distribution and sale of hydrocarbons in the Dominican Republic is governed by the direction of Hydrocarbons of the Ministry of Industry and Commerce (MIC). In 2010, BBLS 37.284.983 of fuels, 1.181.924 cubic meters of natural gas and 41,030 metric tons of coal were imported [5].

Energy graphics

Cayacoa Hotel Annual Energy Consumption (kWh)			
Month	**Electricity**	**Water**	**Gas & Diesel**
January	410.506	89.090	467.892
February	398.817	84.960	377.296
March	418.420	81.385	340.585
April	385.768	82.520	408.741
May	373.140	79.350	393.437
June	450.405	91.505	394.077
July	478.482	119.335	444.812
August	465.021	95.290	437.628
September	434.693	81.685	485.362
October	445.819	86.135	437.234
November	393.544	95.155	455.540
December	370.345	81.140	379.806
Total	**5.024.960**	**1.067.550**	**5.022.409**

Table 7: *Cayacoa Hotel energy consumption data.*

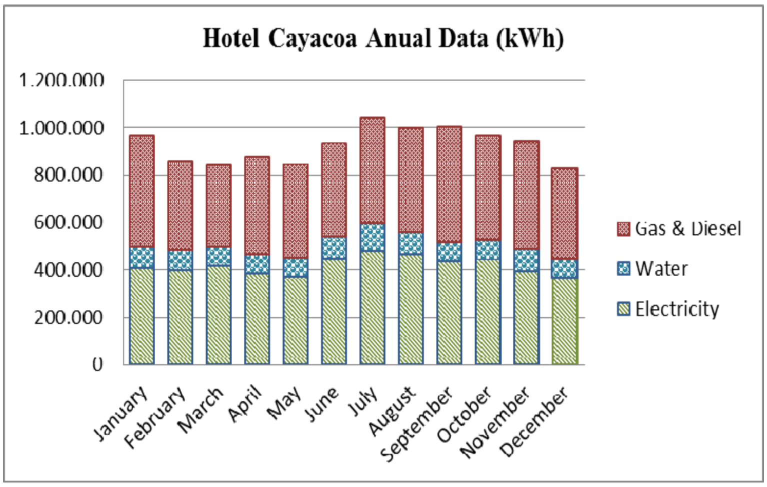

Fig. 3: *Cayacoa Hotel energy consumption figure*

La Tambora Hotel Annual Energy Consumption (kWh)			
Month	**Electricity**	**Water**	**Gas & Diesel**
January	12.480	240	93.578
February	12.000	250	75.459
March	13.560	250	68.117
April	14.520	245	81.748
May	14.520	243	78.687
June	9.960	260	78.815
July	12.360	275	88.962
August	15.120	265	87.526
September	18.360	245	97.072
October	15.480	250	87.447
November	14.400	265	91.108
December	20.400	235	75.961
Total	**173.160**	**3.023**	**1.004.482**

Table 8: *La Tambora Hotel energy consumption data*

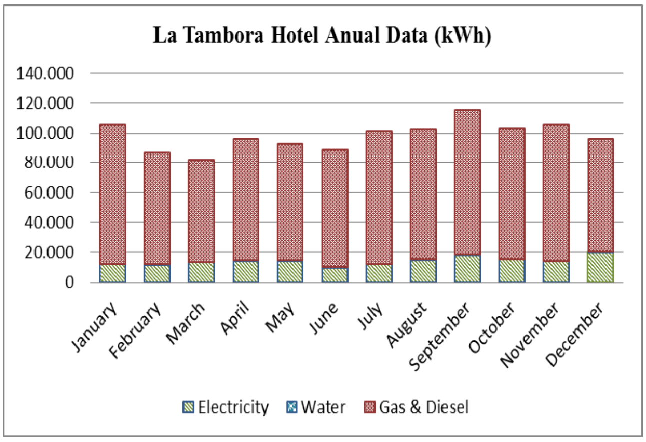

Fig. 4: *La Tambora Hotel energy consumption figure. Water consumption information of is not legible because the quantity is too small.*

Exergy analysis: graphical representation

We shall use an exergetic triangle with 3 vertexes. One of them is related to Energy (red), other to Hydrocarbons (green) and the third to water (blue). In the middle of the triangle it is zero efficiency use and in the vertex is the maximum efficiency.

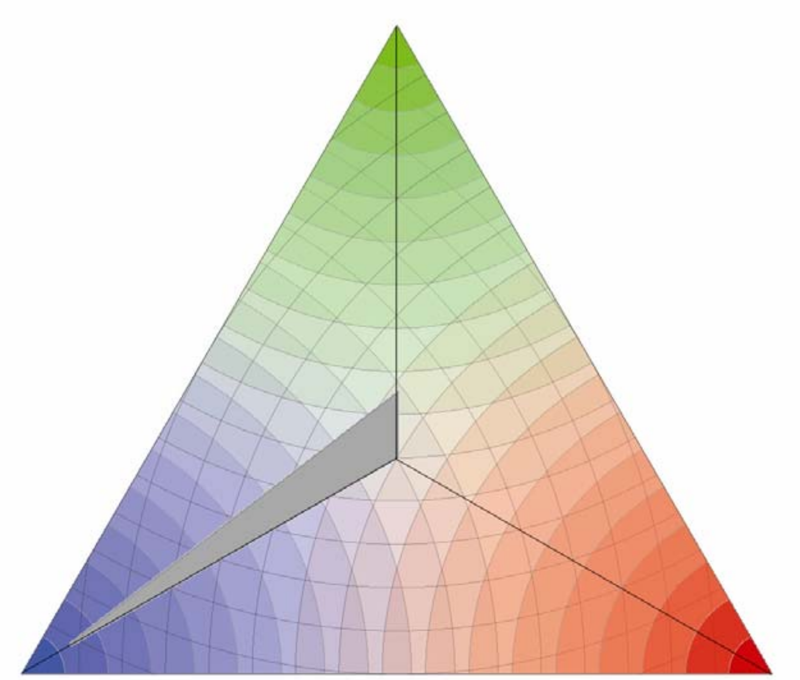

Fig. 5: *Exergetic triangle representing: Electricity (14%), Water (91%) and Hydrocarbons (0%).*

Conclusion

This paper studies the energy and exergy consumed by two different type hotels located in Samaná, Dominican Republic, for the year 2010; the hotel Cayacoa a four star hotel three-star La Tambora. It is clear that the consumption of some resources at both hotels is proportional to the occupation and capacity or type of facilities. We have seen that due to the type of tourists visiting the region, the highest occupancy was recorded in the winter and spring months, from December to May or so. Although in the summer months, the hotel Cayacoa presented a higher occupation, unlike the hotel La Tambora.

Electricity consumption in the hotel Cayacoa is also high in the summer months, even though it had less occupation, due to the use of air conditioners. The interior room temperature (without air conditioning) varies very little from exterior room temperature. Air humidity contributes to the heat sensation, and the absence of natural room ventilation or building isolation, drives the client to use the air conditioning system for longer periods of time. In La Tambora hotel, in general, the consumption goes according to occupancy. The diesel consumption is increased by the use of means of alternate power generation at both hotels. Water consumption is very regular throughout the year, except for the hotel Cayacoa, that in the month of July showed slightly higher water consumption than the rest of the year.

The purpose of this paper is to determine the current status of energy use in hotels in the region of Samaná, to raise awareness and be able to design architectural solutions and facilities that contribute to a better and efficient use of energy. Therefore, it should be taken as a starting point in the development of future planning in the region.

The triangle that we have shown reflects that there are strong difficulties for a country that has more than 75% of its energetic resources comes from abroad. A controlled reduction of consumption appears nowadays as the only solution. This controlled reduction has to be aware of nationals and visitors.

Future development as our group is considering further studies with the help of recognized experts (1).

References

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