Environmental and Energy-Related Impacts in the Operating Cycle of Beach Hotels: Case Studies from the Canton La Libertad, Ecuador

Lourdes Ruiz Gutierrez

International University of Ecuador, Ecuador

Abstract*—*The objective of this study is to determine the appropriate bio-climatic design for the facades of beach hotels that are most exposed to solar radiation, in order to rationalize the energy they consume in climate control (i.e., air conditioning). The methodological approach used consists of identifying adverse environmental impacts in two selected case studies, employing a life cycle assessment of the operation of climate control systems. The results suggest the parameters that should be considered in achieving optimal façade design, to achieve energy savings. The study compares alternatives in the search for design improvements that can optimize energy management during the operational life cycles of hotels located in the southern continental coast area of the country.

Keywords— Energy-Related Impacts, beach hotels.

I. INTRODUCTION

Climate change constitutes a threat that involves, among other things, an annual rise in the average temperature of the Earth caused by increased concentrations of greenhouse gases in the atmosphere, which will result in an increased demand for energy in buildings and an increase in the use of climate control systems employing mechanical cooling methods.

Tourism has complex relationships with weather and climate, and there is consensus that tourism could be substantially affected by climatic change [1]. Tourism is one of the most climate-sensitive economic sectors, but also a contributor to climate change. With the effects of climate change becoming an increasing concern, the tourism sector must urgently and realistically respond by mitigating its emissions and adapting tourism businesses and destinations to the changing climate conditions [2].

Tourist facilities in coastal ecosystems often cause undesirable environmental impacts, also known as negative environmental impacts, and have severely affected natural vegetation, wildlife habitats, landscapes, soils and wetlands as a result of construction activities [3].

The widespread development and use of quarries, excessive clearing of vegetation, filling of lakes, and other actions that cause severe damage to the environment can be avoided using design and technological measures that are appropriate for the valuable resources where it takes place [4]. Most tourist facilities that have been built do not include environmental and landscaping considerations in their planning and forecasting. This situation is due to ignorance or lack of environmental consciousness about how to intervene in coastal areas with high ecological fragility and sensitivity without causing severe environmental impacts, and a lack of integration of the conceptual ideas to harmonize necessary tourism development with sustainable approaches and practices. The regional level has been recognized as a good scale for implementing actions towards sustainable development [5].

Tourism is an economic vehicle for historic towns, providing it is undertaken with a focus on sustainability, based on respect for the indigenous culture, the environment and tangible and intangible cultural heritage. Sustainability implies a rational relationship between man and nature; changes which affect the natural environment impose limits which should be analyzed prior to creating disturbances therein [6].

The application of methods of environmental analysis in the field of urban heritage for tourism allows the study and assessment of the actions created by the planning activity, with a view to determining, predicting, interpreting and communicating the negative impacts that these actions cause in the environment under current conditions, in order to reach a social model with approaches to sustainability in tourism [7].

Bioclimatic architecture has developed over many years to address the problems inherent in buildings. Through a process of trial and error our ancestors have found effective

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ways to handle the different climatic conditions. All through history, people were trying to adapt their buildings with the environment in order to create better living conditions [8].

Climate is one of the most decisive factors in bioclimatic design, because it influences both the temperature and the type of construction to be carried out, along with other factors such as wind patterns, relative humidity, the local urban climate, external vegetation, etc. Climate adaptation, energy efficiency, sustainable development and green growth are societal challenges for which the Facilities Management profession can develop solutions and make positive contributions on the organizational level and with societal-level effects [9].

Hotels located in warm coastal areas demand the use of refrigerated climate control systems, the need for which can be reduced if bioclimatic designs are employed in the building faces that are most exposed to solar radiation and therefore subject to an adverse gain of interior heat.

Environmental and energy-related impacts in the operating cycle of beach hotels occur in the coast of western Ecuador, in the center of the world. These cases of studies are located a canton La Libertad, within the Province of Santa Elena, along the coastal zone of Ecuador. This canton of Ecuador is home to 95,942 people according to the VII Population Census conducted in 2010, and according to the National Census and Statistics Institute (INEC), it is the most populated city of Santa Elena. The local economy is based around tourism, fishing and oil production [10].

The geography of La Libertad is irregular and includes a small mountainous system called La Caleta. The surface area of the canton is approximately 28 square kilometers. Its average annual temperature is 28 degrees centigrade, and in December the temperature varies between an average high of 32°C, and an average low temperature of 20 °C. This zone is very dry, and so it has salt plains and scarce rainfall [10], [11].

II. MATERIALS AND METHODS

This study used the methodology of PRé Consultants [12], to assess the life cycle of the projects, and specifically the following tools:

- SimaPro, designed for performing Life Cycle Assessment (LCA) in order to give preference to improving products or processes and comparison between products.
- Eco-indicator’999, an impact assessment methodology that assigns impacts to three types of damages: human health, ecosystem quality and resources.
- Ecoinvent (Switzerland), a database containing 2700 industrial processes used in a variety of sectors such as energy, transportation, construction materials, chemicals, cleaning agents, paper, agriculture, waste management.

LCA (Life Cycle Assessment) is considered to be the scientific discipline which measures the consumption of energy and material resources and the environmental impact created by a product over its useful life. Through comparing data, designers can, at least in theory, select the materials and components that cause the least environmental damage [13].

According to Fuller, (2005) of the National Institute of Standards and Technology (NIST), the LCA is especially useful for comparing alternatives in a product that meet the same requirements but differ with respect to the initial costs and operating costs, in order to select the one that maximizes net savings [14].

In order to determine the environmental impacts resulting from the operational cycle of beachside hotels, in this study an LCA was carried out using the Demo Simapro7, and the Eco-indicator’99 method along with the Ecoinvent database, [12].

In this process, determined the selected variables that primarily influence the solar heat gain admissible in the facades of hotel rooms facing south, with an estimated surface area of windows in the southern façade of 9.00 square meters until 16.00 square meters. The methodology employed in this study [15], does not consider relative solar heat gain, which would imply measuring other more complex variables, such as heat supplied through glass in normalized conditions with humidity levels in interior spaces and direct and diffuse solar radiation.

III. RESULTS AND DISCUSSION

The LCA was used to evaluate energy performance during the hotel operations phase, with the admissible solar heat gain per functional unit during the month of December. The thermal simulation for both case studies assumes a daily air conditioning program used in the month of December 2015, between the hours of 10:00 a.m. to 3:00 p.m., with an average temperature of 28°C.

Only five variables were selected as the most influential in solar heat gain, which were the following [15]:

- Orientation of the hotel façade, for which the south-facing façade was selected. This is because of the density of solar radiation corresponding to the southern faces of buildings, which occurs practically during the entire year, and throughout the entire day.

- The surface area of windows in the southern façade, with aluminum frames and fixed transparent glass panes with a thickness of 4 millimeters [16].
- The width of awnings hanging over the windows to shade the sun.
- The area of concrete blocks in the southern façade.
- Permissible solar heat gain coefficient, which is the heat gained through the opaque and transparent parts of the southern façade of the building.

The thermal simulation study allows us to identify the correlation between the design variables, the height of the glass window and projection of shade elements and the solar heat gain and electricity consumption used in cooling, which can be summarized as follows: the higher the window, the higher the solar gain and the electricity consumption used in climate control, while the larger the projection of the shade element, the lower the solar gain and the lower the electricity consumption needed for cooling, [153].

Table 1 shows the comparative data from the two selected case studies. The differences between the facades are due to the fact that in case 2, the surface area covered by aluminum-framed windows with fixed 4 mm-thick glass is much smaller, the surface area of concrete block walls is similar, but there is an awning or shade over the window with a width or projection of 1 meter.

Table.1: Comparative data from the selected case studies

Selected variables	Case study 1	Case study 2
Orientation of the hotel façade	South	South
Surface area of aluminum-framed windows with 4mm transparent glass	16.00 square meters	9.00 square meters
Width of awnings over the windows	0.30 linear meters	1.00 linear meters
Surface area of concrete block wall	40.25 square meters	39.50 square meters
Permissible solar heat gain coefficient	0.30	0.40

The permissible interior heat gains from thermal loads (during the hot season) are considered constant in both case studies. Heat enters due to sun exposure on glass-covered openings (windows), increasing the ambient temperature. This effect is unfavorable in hot areas, since it increases interior temperatures.

The goal of the simulation is to determine the amount of electricity consumed to cool the interior environment. Two models are created which combine the selected variables. Both case studies of hotel rooms are done during the operational phase, which is the most significant in terms of energy expenditure. For the life cycle assessment (LCA), the functional unit is one square meter (1 m^2) of south-facing façade, with an estimated area of 40 m^2.

The other elements which comprise the space of the room, such as the structural and other elements of the building, which are primarily made of reinforced concrete, were not taken into account in this model, since their large consumption of natural resources and energy and their significant impacts are an impediment to being able to isolate the data related to the study variables, and therefore they are not included in the analysis.

The comparison of the final environmental impacts in case studies 1 and 2, demonstrate the high levels of fossil fuels consumed by air conditioning, and the contribution of adverse environmental impacts due to climate change.

One also sees the close correlation of the inappropriate design of the area comprised of windows with aluminum frames and transparent 4mm thick glass panes, which covers half of the façade, without any shades or awnings over the windows during the hours of maximum solar exposure, from 12:00 noon to 3:00 p.m., represented in case study 1 of standard hotel rooms. In case 2, there is a significant reduction in fossil fuel-generated energy consumption in the climate control function, because the design of the windows is more rational and 1.00 meter-wide exterior awnings shading the windows of the southern face (Fig. 1).

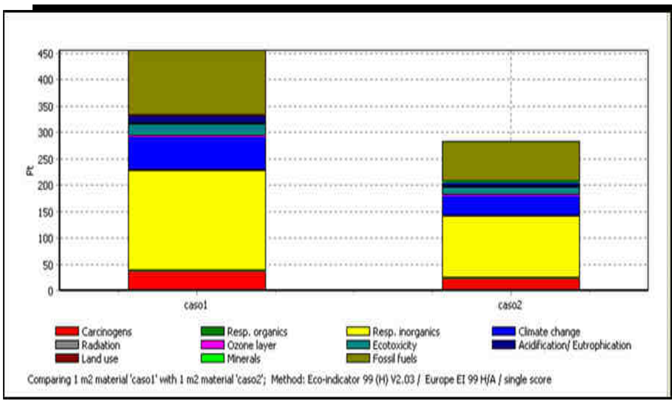

Fig. 1:Comparison of the endpoint environmental impacts in case studies 1 and 2 in selected hotel rooms.

In designing the shell of climate-controlled buildings, it is advisable, as a general guideline, to use windows whose total surface area is equal to or less than 25% of the surface area of wall, to protect them from direct solar radiation, and to take into account, when selecting materials and products, the energy involved in the processes during their life cycle.

The results indicate that in most of the impact categories, the main influence is in terms of energy, fuels and electricity, due on the one had to the long period of use, and on the other, to the aggressiveness of the heat generation processes. This study found that by reducing the proportion of window area on the southern façade, and protecting the windows with a 1-meter awning, the hotel can reduce its average annual consumption of electricity for air conditioning by 50%.

This study shows the benefits, from an environmental point of view, of reducing solar heat gain in interior spaces of climate-controlled hotel rooms in the La Libertad canton of Ecuador, resulting in reduced cooling and energy consumption requirements during the useful life of the building.

IV. CONCLUSIONS

- Hotel buildings consume large amounts of natural resources, and are a source of environmental contamination, and excessive energy consumption is the cause of most of these impacts.
- The study conducted here constitutes a method for modeling bioclimatic conditions to be used in designing facades of a climate-controlled hotel. The life cycle assessment carried out demonstrates the significant impact that inappropriate designs have on the quantity of energy consumed during the operational phase of air-conditioned hotel rooms, and the usefulness of the life cycle assessment approach in terms of its application to building design.
- The assessment makes it possible to evaluate the potential impacts, by damage categories (human health, ecosystems, and natural resources) produced by various construction materials included in the study, as well as the use of energy (fuel and electricity) in all of the processes. The designers now have access to updated tools that will assist them in considering energy management and sustainability criteria in designing climate-controlled hotels.

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