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Architecture in Conservation Areas - Humboldt Hotel, Caracas, Venezuela

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Abstract

The following study provides the latest environmental strategies to reduce the building's energy consumption and mitigate the environmental impact that the Humboldt Hotel will have during the life cycle of the building.

As a result, a compilation of historical data from official sources is provided, as well as a technical investigation through Revit Insight and Designbuilder programs to evaluate the energy performance of the building and provide a timely and assertive action plan.

Keywords: *Designbuilder, Hotel Humboldt, Radiation Analysis, Environmental Impact, BIM model, Energy Consumption Analysis.*

1. Introduction

The Humboldt Hotel, located in the city of Caracas, Venezuela, is an iconic work of Venezuelan architecture conceived by the renowned architect Tomás José Sanabria. (Brillembourg, Carlos. 2008). This work pays homage to the explorer Alexander von Humboldt (Sanabria, Tomás. 1957) with its name, the hotel was built in the 1950s and illustrates and accompanies the country's socio-political historical trajectory. (Gómez Rico, Verónica, and Andreina Méndez Antonetti. 2008). Since its conception, this hotel has experienced a tumultuous operational life marked by various closures, changes in its management concession, and prolonged periods of inactivity dating back to 1986. (Gonzalez Capitel, Antón. 1996) In pursuit of the reactivation of this emblematic work of the capital city (Sanz, Pedro. 1997) (Lameda, Hernán. 2017), restoration and remodeling of the hotel facilities is proposed, a project that began in 2000 and concluded in December 2020. However, in emblematic works like these, restoration is focused on conserving the essence and original work of its author, (Vertullo, Gregory. 2019) often overlooking or omitting the importance and innovation of its construction and/or environmental solutions. This paper presents the historical trajectory of the Humboldt Hotel and its surroundings, (León, María Gabriela. 2014) the technical analysis of its remodeling and restoration through bioclimatic tools to evaluate the relationship between major architectural projections and constructions, and their adaptation to new environmental criteria and requirements today.

2. Objective

1.1. General Objective:

Evaluate sustainability strategies applied to using the Humboldt Hotel to reduce energy consumption and mitigate environmental impact.

1.2. Aims:

Analyze the energy behaviour of the building and its environment;

Calculate the environmental impact of the Humboldt Hotel focused on energy consumption during the operational phase of the building;

Identify sustainable strategies to reduce energy consumption during the operational phase of the building;

Quantify the building's energy reduction and environmental impact based on the proposed sustainable strategies.

3. Methods and/or procedure

- Analyse the energy behaviour of the building and its environment;
- Calculate the environmental impact of the Humboldt Hotel focused on energy consumption during the operational phase of the building;
- Identify sustainable strategies to reduce energy consumption during the operational phase of the building;
- Quantify the building's energy reduction and environmental impact based on the proposed sustainable strategies.

4. Results

A historical record of the changes undergone by the hotel from its inception to the latest rehabilitation is made in BIM software, highlighting the collapsed and new elements (Figure 1).

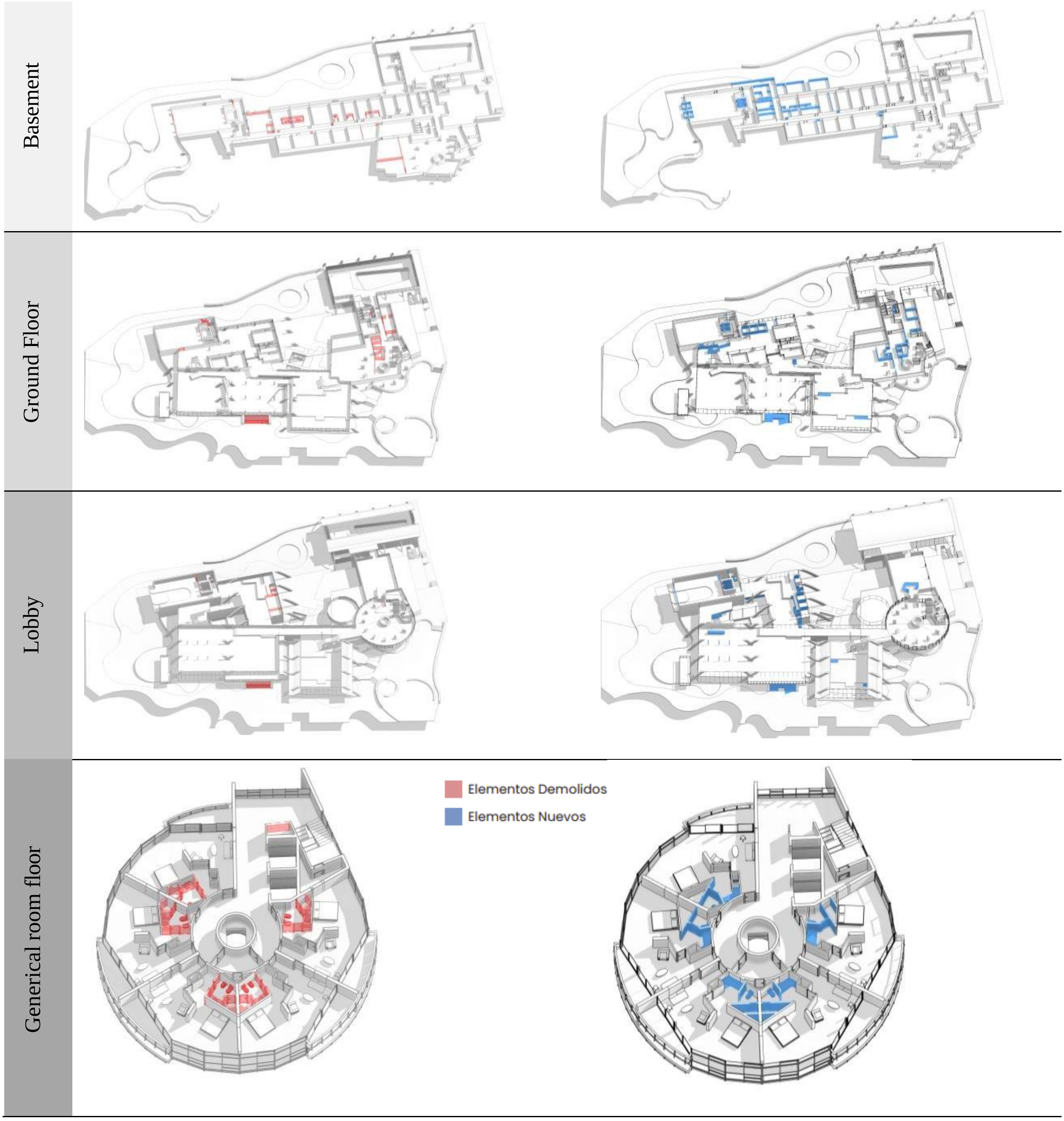


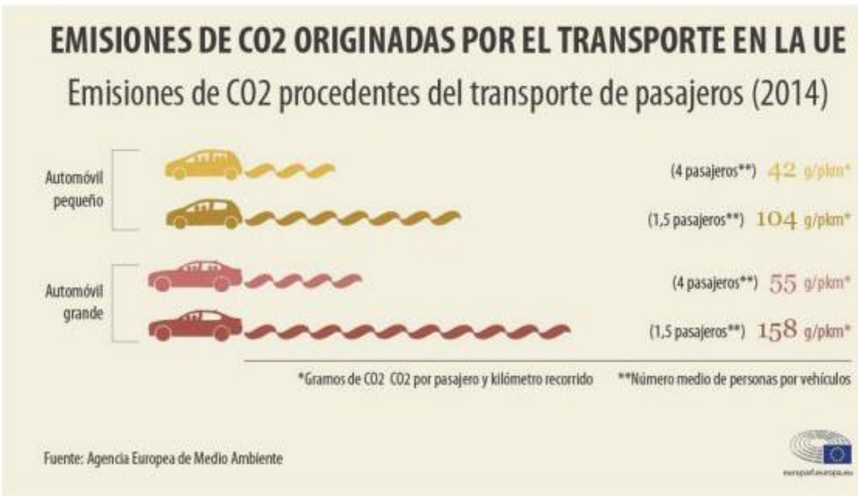
Figure 1. Demolished Elements. Own Source

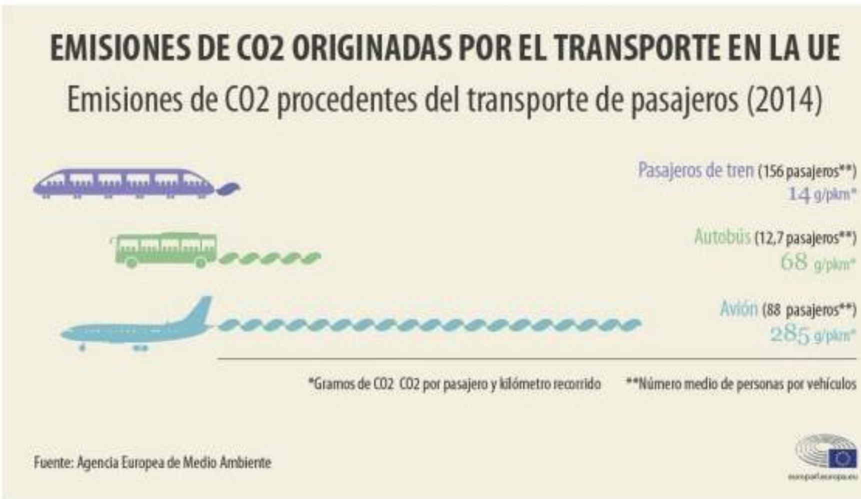
Environmental strategies related to mitigating the environmental impact of the Humboldt Hotel are the following:

1.1. Transport and Accessibility

The cable car transport system not only significantly contributes to the accessibility of the Humboldt Hotel but also reduces the carbon footprint and environmental impact on the park (Figure 2). (Biberos-Bendezú, Karen, and Ian Vázquez-Rowe. 2020). Based on the grams of CO^2 produced per person per kilometre in diverse types of transportation according to the European Environment Agency (2019), (Sandó Marval, Yovanna. 2011) a comparison was made between the cable car system of Ávila and a four-wheel-drive car, considering the following variables:

- Generating 1 GW/h of energy in Venezuela produces approximately 307.4 TCO^2/Gwh. (Osal & Pérez, 2019);
- The average energy consumption of the entire cable car system is 415 Kw/h. (Source: Doppelmayr) Considering that for one hour, six complete trips are made with 82 operational cabins, approximately 1.960 people can be transported per hour;
- The approximate energy consumption per person per kilometre of the cable car system is 4.39x10^-8 Gwh/p.km. Calculations are based on the total energy consumption e of the cable car system, the distance of travel, and the capacity of transportation;
- The Cable Car's inclined length (with slope) from the San Bernardino station to the Ávila station is 3,463.77 meters;
- A four-wheel-drive car emits 55 and 158g of CO2 per passenger per kilometre (European Environment Agency, 2019);
- The distance by SUV drive car from the San Bernardino cable car station to the Humboldt Hotel is 11.6 km, while the Cable car system is only 3.5 km. The results of the analysis between the two means of transportation used to travel to the Waraira Repano Park show that the cable car system has an approximate CO^2 emissions savings between 3.59% and 32% per kilometre travelled, considering the minimum and average demand of users in this transportation system. (Brida, Juan Gabriel, Manuela Deidda, and Manuela Pulina. 2014) It is noteworthy that the travel distance between both transportation systems is different due to the difficulty of accessibility in the area, further accentuating the advantages of using the cable car system.





Cuadro 2. Emisiones **de GEI** por la generación de energía eléctrica (t/GWh) para Venezuela en el periodo 2006 – 2017.

Gas	Año											
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CO_2	196.76	181.58	252.59	270.64	261.73	233.60	263.54	251.54	251.40	316.19	298.26	307.40
CH_4	0.0148	0.0138	0.0241	0.0252	0.0259	0.0228	0.0256	0.0251	0.0193	0.0249	0.0265	0.0273
N_2O	0.9575	0.8865	1.4369	1.5208	1.5156	1.3385	1. 5164	1.4662	1.2382	1.5682	1.6087	1.6567

Fuente: Osal W, Pérez R.
Artículo de Investigación
Universidad Nacional Experimental Politécnica Antonio José de Sucre, Barquisimeto, Ven.

Análisis comparativo de Emisión de CO2 por sistema de teleférico
Fuente: Propia

Figure 2. Comparative analysis of CO^2 emissions in the transportation system. Own Source

1.2. Interior Space Quality:

The room tower of the Humboldt Hotel (the most relevant and prominent space of the entire complex) is selected to create thermal simulations using DesignBuilder software. These simulations are classified into three scenarios:

- Initial Situation (Inauguration);
- Current Situation (Current Rehabilitation);
- Proposal (Traditional panels are replaced by photovoltaic panels and the simple exterior glazing of 6mm thickness by double-glazed photovoltaic glass with an SHGC of 0.40). The choice of material is due to its innovative technology that allows capturing energy and reducing solar radiation. Additional,

A layer of 6cm of fibreglass thermal insulation is added to the intermediate floor. Initially, natural ventilation is considered to establish the possible differences in the behaviour of the chosen construction materials and their impact on the thermal comfort of the space.

All simulations consider construction, climatic, and human parameters, such as:

- Climatic factors of the sector (Orientation, altitude, winds, temperature, radiation, humidity, etc.) from an EPW bioclimatic file of Meteonorm software, which interpolates different sources of climate information from the sector to obtain more accurate environmental information. In this file, it can be observed that right in the immediate surroundings of the Humboldt Hotel, the climate presents the following characteristics:
- Construction materials with their respective thermal transmission properties. (Materials and their original dimensions as insulators are assumed; others are deduced through photographic collection during the building rehabilitation process);
- Shadow elements or any adjacent physical element that may interfere with energy results - Programming of use (Schedules and activities) and space capacity.

Regarding the comparative analysis of the energy gains of the three simulations, it is observed that the results of the proposed simulation are much lower compared to the previous simulations, reaching an annual solar radiation gain of 1,144.35 Kh/h. This figure represents only approximately 35% of gains from radiation compared to the original design and rehabilitation simulation of the Humboldt Hotel (Figure 3).

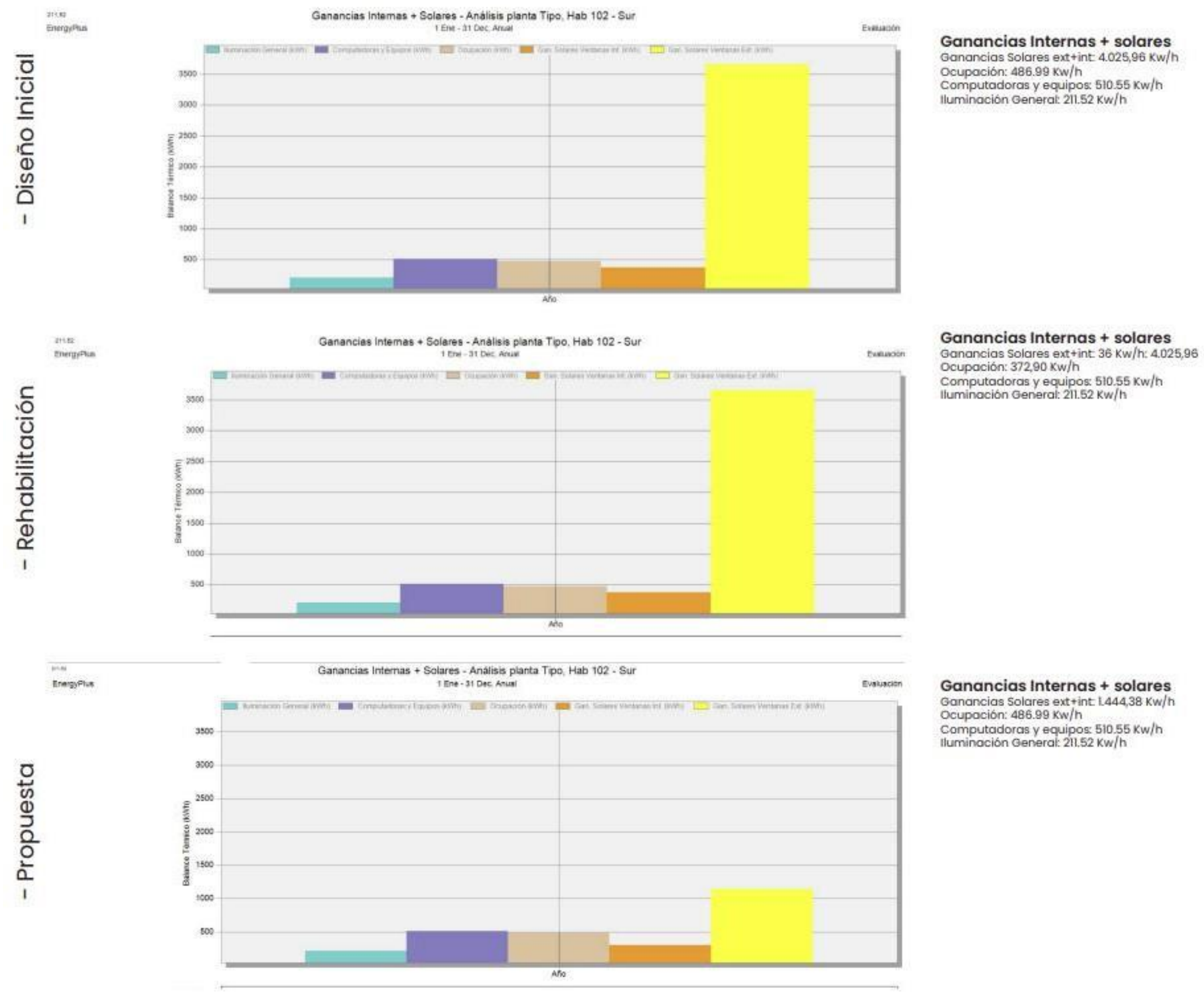


Figure 3. Comparative analysis of energy gains in the south room of the Hotel. Own Source

To objectively evaluate the three scenarios and determine a more efficient outcome regarding thermal comfort, the adaptive comfort standards established by ASHRAE 55 (2017) are used as a basis. Based on this comfort standard (Humphreys, M. 1994), a comparative analysis of the room with the highest temperature peaks is conducted across the three simulation scenarios presented (Original Design, Rehabilitation, and Proposal). The Adaptive Comfort Building Environmental (CBE) graph results indicate that thermal comfort is achieved in the "proposal" simulation, unlike the previous simulations. This highlights that the use of double photovoltaic glass with a low solar transmittance coefficient would significantly benefit the project by providing more hours of comfort to hotel users.

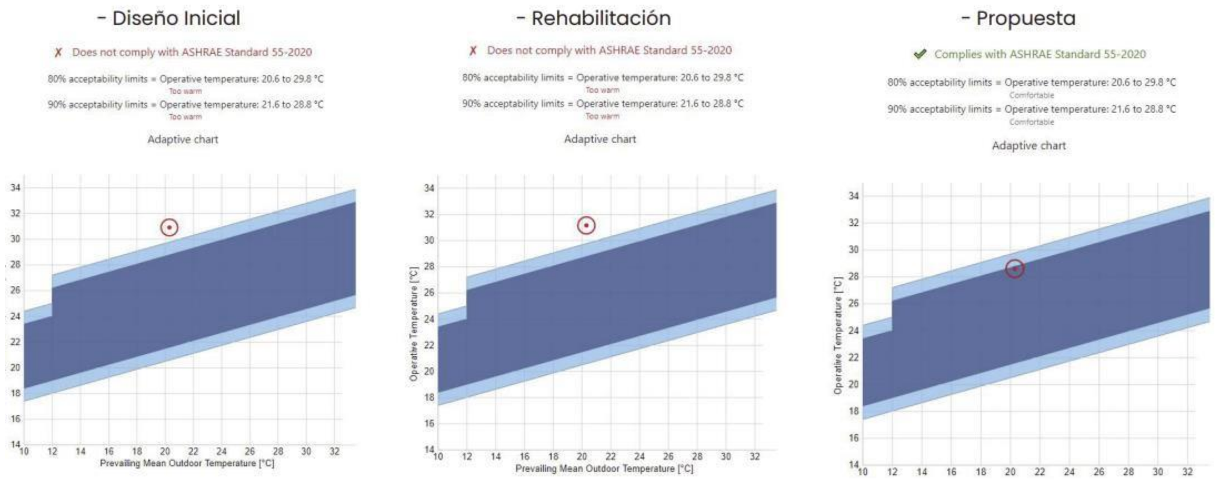


Figure 4. Comparison of Adaptive Comfort of the three scenarios. CBE thermal comfort tool. (confort.cbe.berkeley.edu/). Own Source

1.3. Energy Optimization.

Based on the simulations carried out in DesignBuilder for the three scenarios, we can estimate a hypothetical electrical consumption of the rooms in the tower of Hotel Humboldt regarding cooling/heating, hot water, equipment, and lighting. (Gössling, Stefan. 2012)

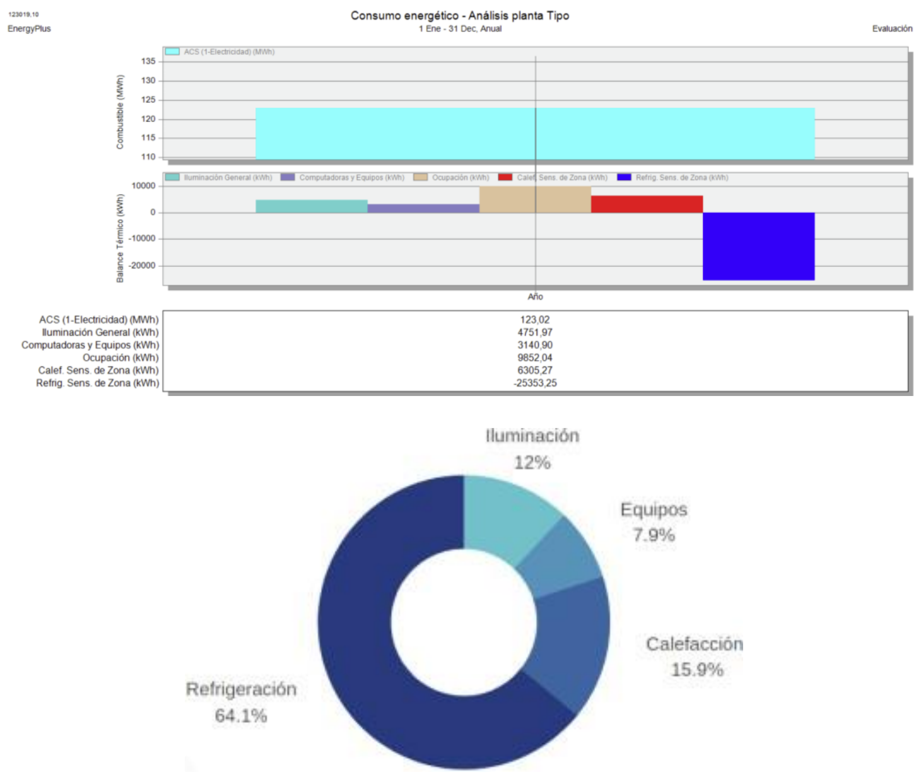


Figure 5. Approximate distribution of energy consumption of the Humboldt Hotel type plant. Own source

The results of the thermal comfort simulations show that solar radiation is one of the main sources of energy acquisition that can generate thermal discomfort in the afternoon due to overheating the operative temperature.

Therefore, it is quite important to harness this energy source to reduce the building's energy consumption and mitigate the environmental impact during the life cycle stage.

A radiation analysis is made on all elevations of the room tower and the vaulted roofs to determine the amount of radiation these surfaces receive. Critical days of the year (solstices and equinoxes) are analysed, as well as the cumulative radiation over a full year. The daily radiation analysis on roofs shows that solstices are the least favourable days for radiation, with a daily energy accumulation of up to 9,502 kWh with an average of 2.54 kWh/m^2 in winter and up to 7,290 kWh daily with an average of 1.95 kWh/m2 in summer. On the equinox, days show that the daily energy accumulation in spring can be up to 13,844 kWh with an average of 3.70 kWh/m2 of surface. In autumn, an energy accumulation of up to 12,948 kWh with an average of 3.46 kWh/m^2 of roof surface can be obtained. In the daily radiation analysis, the envelope shows that, like the roofs, the most favourable radiation days are the equinoxes, with daily accumulative radiation of up to 6,214 kWh with a distribution of 1.65 kWh/m2 in autumn and up to 5,973 kWh with a distribution of 1.59 kWh/m^2 in spring. In contrast, on the winter and summer solstices, the daily accumulative radiation is 5,899 kWh and 3,400 kWh, with a distribution of 1.57 kWh/m^2 and 0.90 kWh/m^{2,} respectively (Figure 6).

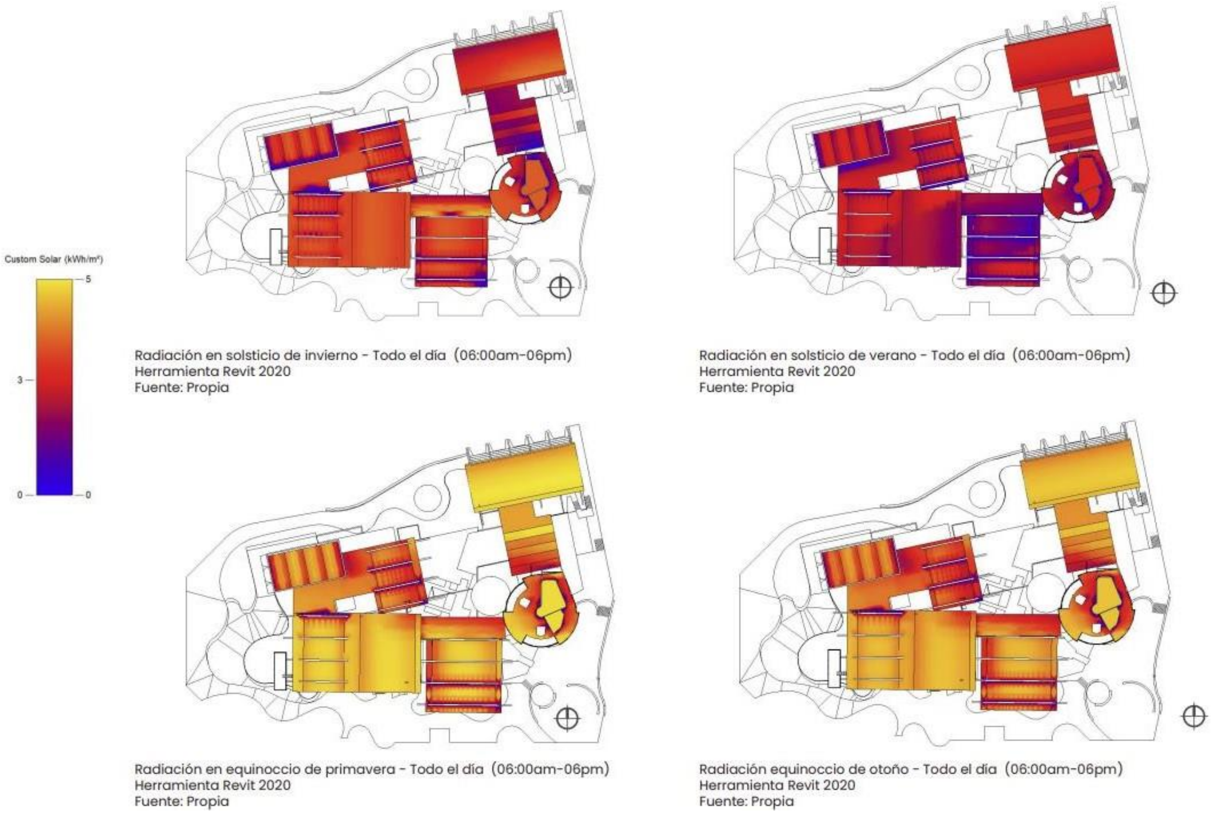


Figure 6. Radiation Analysis on Solstices and Equinoxes. Own source

The values obtained in the annual radiation analysis indicate that on the total surface of the Hotel Humboldt tower (3,993 m^2), it receives a direct solar radiation of 2,016,800 kWh accumulatively throughout the year with an average of 505 kWh per square meter of surface (kWh/m^2). In comparison, the roofs represent 3,506 m^2 and receive an annual radiation of 4,004,078 kWh with a distribution of 1071 kWh/m^2 (Figure 7).

Overlaying the shadow chart for the critical days of the year, we observe that only a minimal portion of the hotel complex achieves 100% efficiency. The most optimal areas for efficient energy caption are the roofs of the room tower and the vault of the pool, where very few days of the year are projected. Most roof surfaces have an approximate efficiency range of 35-50% (Figure 8).

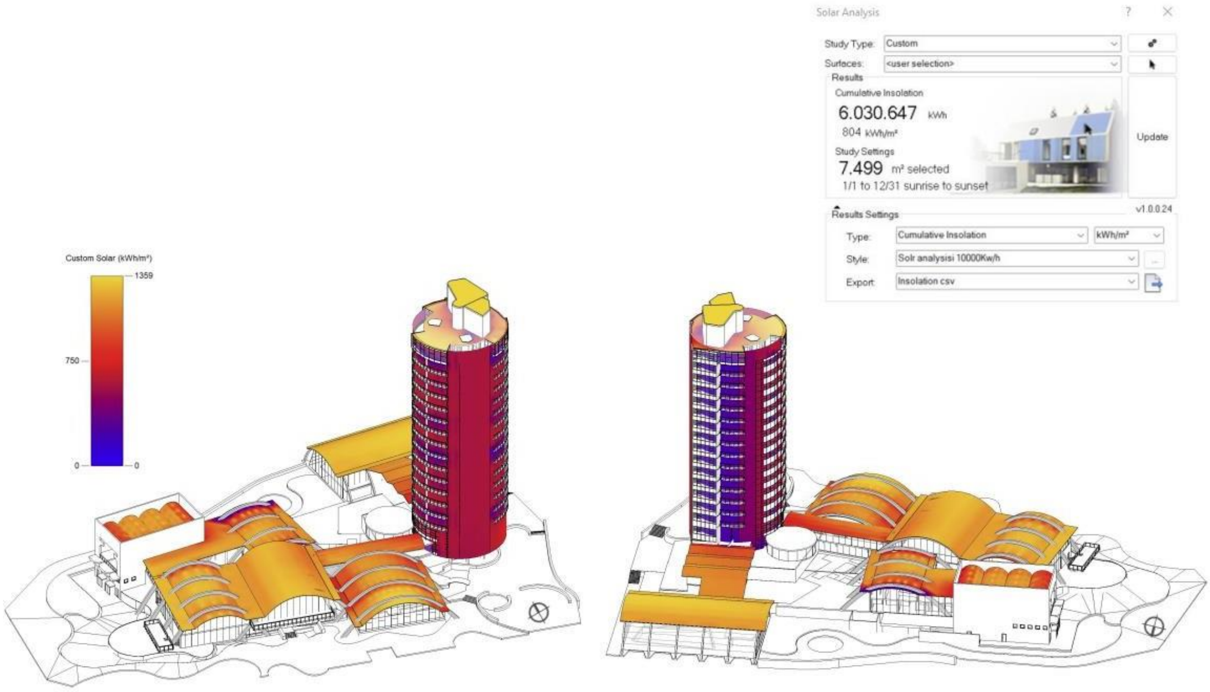


Figure 7. Annual Radiation Analysis. Own source

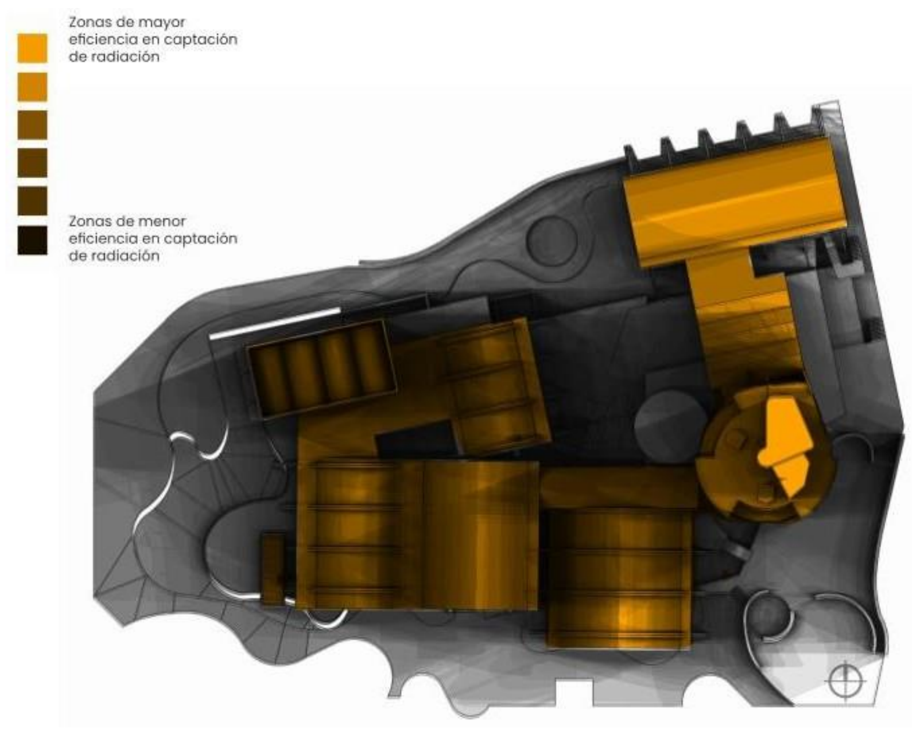


Figure 8. Efficiency analysis. Shadow Card. Own Source

Like the hotels in the Caribbean and those in Bogotá, as discussed in the research article by Jarba, M. and colleagues (2014), Hotel Humboldt shows higher consumption in the air conditioning category. With the total energy consumption of a typical floor, it is estimated that the approximate energy expenditure of the room tower of Hotel Humboldt is 553,713.46 kW/year. If photovoltaic materials are implemented throughout the hotel complex, enough energy would be generated to cover up to 80% of the tower's consumption (Figure 9).

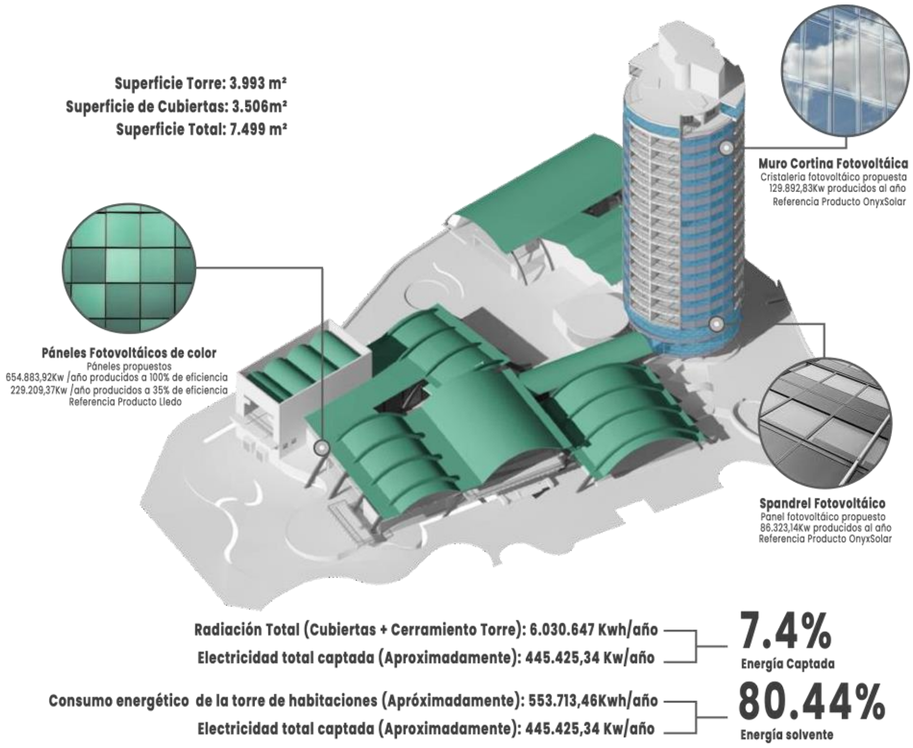


Figure 9. Photovoltaic materials implementation chart. Own source

1.4. Lighting Analysis

A comparative analysis of natural lighting is conducted between the original design scenario and the proposed design of the Hotel Humboldt Tower. In both cases, similar behaviour is observed regarding the distribution of natural lighting, with parameters ranging between 200 and 1000 lux in the rooms, with the perimeter area being the most benefited in terms of illumination, while the central core of the building has values below 100 lux. The proposed design has a clear reduction in perimeter natural lighting compared to the original design due to the material change in the envelope glazing. Based on Spanish regulation UNE12464.1, the table of areas of public access in hotels states that corridors must have minimum acceptable values above 100 lux. Therefore, implementing efficient artificial lighting is necessary to meet these requirements. No parameter or similar space is observed in regulation UNE 12464.1, indicating the minimum lux required in the rooms (Figure 10).

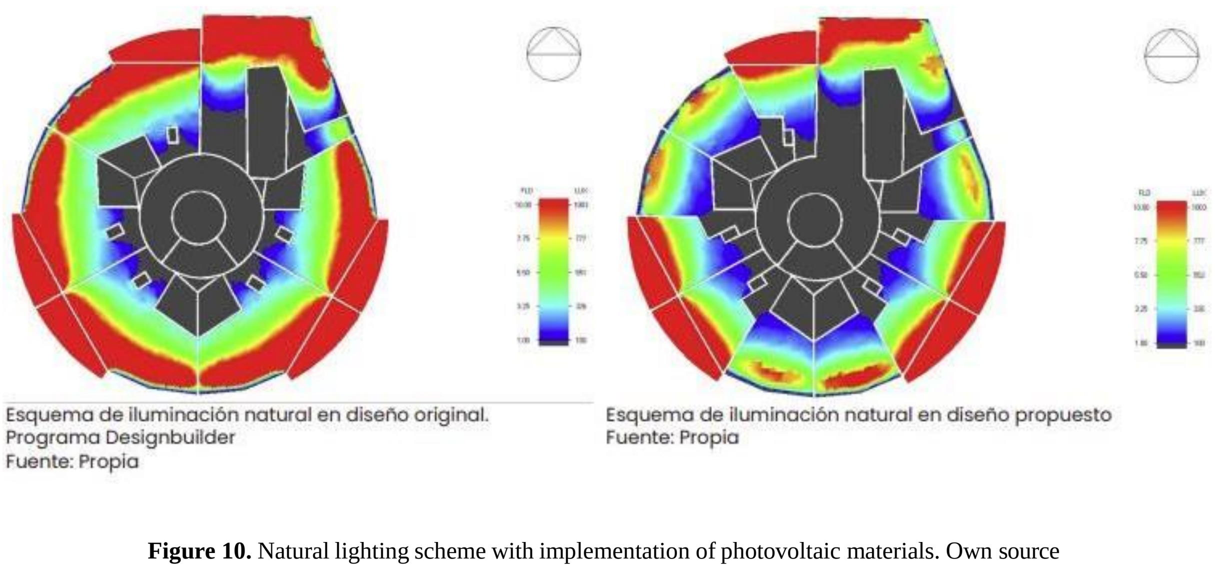


Figure 10. Natural lighting scheme with implementation of photovoltaic materials. Own source

5. Conclusions

Based on the compilation and analysis of information in this research work, the following general results can be defined:

- The Humboldt Hotel is a unique project (Unamuno, Miguel De. 1980)with significant historical value due to the country's situation at the time of its construction.
- The Humboldt Hotel is a privileged project with landscape value, thanks to its location allowing 360-degree views of the Caribbean Sea and the capital city, surrounded by fauna and vegetation typical of a protected natural park, according to the National Parks Institute of Venezuela.
- The hotel complex has great architectural value, and its possible preservation would allow this project to be classified as one of the most important modern landmarks in Latin America, as it possesses significant cultural, constructive, and historical value.
- On numerous occasions, attempts have been made to reopen the Humboldt Hotel. However, no detailed analysis of the project's problems, such as its profitability (one of the initial major issues), is evident, nor is there any indication of optimal building use or alternative accessibility plans in case of any failure in the cable car system.
- Due to its remote location, the project may be difficult for people with disabilities to access; however, ramps and elevators are observed in the rehabilitation process.
- The cable car system is essential for the operation of the Humboldt Hotel, and its use mitigates the environmental impact by 5% to 32%, depending on its use, compared to an SUV.
- The rehabilitation of the Humboldt Hotel follows the guidelines of the original design proposed by the architect Tomás José Sanabria, evoking a sense of nostalgia from the 1950s through the finishes, textures, materials, and furniture used, where every detail was meticulously studied and analyzed; however, environmental analysis was not one of the priority aspects for decision-making regarding the implemented reforms.
- The thermal performance of the hotel complex has deficiencies. The originally proposed envelope and reform do not optimize their possibilities to maintain temperatures within the thermal comfort range defined by ASHRAE (2017) standards.
- Regarding technological innovation, a home automation system for curtains is noted; despite this innovation, current equipment and systems were not considered for automated management for efficient climate control. The implementation of strategies, equipment, and/or materials focused on reducing the natural resource consumption of the hotel complex has also not been observed.
- Incorporating photovoltaic materials in the building could significantly reduce energy consumption, reducing around 136.92 TCO2 per year.
- The proposed photovoltaic glasses with low SHGC would provide more thermal comfort to users during peak radiation hours.

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