Indoor Environmental Quality design of hotels in the United States and Europe

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ABSTRACT

The last 50 years marked a deep change in the way people travel. The great development of tourism created the necessity of building more and more hotels and accommodations, polluting and wasting much energy. The aim of this research is to understand how the accommodations face the environmental impact of the structure using LEED parameters. The starting point is the analysis based on a survey made on a sample of hotels located in places with opposite climate conditions; the purpose is to understand which strategies the structures adopted in order to adapt to extremely different climate conditions.

Key Words: **LEED certification**, **indoor environmental quality**, **Hotel environment**, **tourism**

1. INTRODUCTION

1.1. The impact of tourism

From 1950s to nowadays tourism experienced a 49 fold increase, passing from 25 million global tourist arrivals to 1.2 billion in 2016[1]. This incremental growth in the number of travelers consequently led to a raise in demand of tourist accommodations such as hotels. The hospitality industry is among the most polluting in the world because:

- hotels are one of the few architectures that work every day of the year and both night and day;
- particularly electricity is the most wasted resource, taking between 60% and 70% of the consumption costs, of which 25% is represented by lights. Overall this means a doubled consumption per night compared to 50 years ago[2].

Moreover, tourists are getting more conscious about the environmental issues, and they are consequently more interested in the greening of tourism. In fact, more than one third of the travelers pay attention about their choices in order to become "greener" tourists. Furthermore, both ecotourism and cultural tourism are taking the lead and are predicted to grow rapidly over the next twenty years. It is estimated that global spending on ecotourism is increasing about six times the industry-wide rate of growth[3]. In this context, the LEED - Leadership in Energy and Environmental Design- parameters could be used as a valid help to understand how eco-sustainability could bring an improvement for both the environment and the economy of the hotel industry.

1.2. LEED and IEQ

The LEED certification was created by the United States Green Building Council (USGBC) with the aim of promoting sustainability in the building and construction industry[4]. The LEED works through the evaluation of parameters, such as the IEQ (Indoor Environmental Quality), used to rate the quality of the environment surrounding the guest.

The IEQ is based on multiple parameters[5]:

- IAQ (Indoor Air Quality)
- artificial and natural ventilation
- the thermal comfort
- the interior lighting
- the daylight
- the view and
- the acoustic performance

Therefore, through their use the LEED parameters can guarantee a more satisfying stay for the travelers and a reduction in the environmental print left by the structure. Nonetheless researchers found out that there is no specific evidence of an implement in the revenue of the building certified with LEED, even though a slight difference can be spotted; the research anyway is based on a very few structures (93 certified hotels) that may not be enough incisive in the data analysis. The absence of utter proofs of bigger revenues can be one of the possible explanations for the lack of LEED certified buildings. On the other side, the LEED certification could provide a good standard to be featured in building projects in order to create greener constructions. Indeed, the parameters of LEED certifications concern many steps of the project, such as the water saving systems and paintings with low contaminants[6]. Including these parameters in the project and later in the development of the architecture could produce benefits both for people and revenues: a healthy and comfortable stay for the guest, and a cut in the consumption of resources through saving systems and renewable energy.

2. AIM AND METHODOLOGY

The aim of this research is to study which solutions the hotels engaged in to solve climate issues, according to the specific climate condition.

Among the LEED parameters, the research focused explicitly on the IEQ of the rooms considered.

A survey has been developed on quantitative data and has been distributed to the chosen hotels after contacting via phone call the general manager of the hotels and being sent by postal services. After a month, the general managers have been contacted again so that they could send back the results via mail or e-mail.

[1] See https://ourworldindata.org/tourism
[2] See https://www.calrecycle.ca.gov/EPP/GreenLodging/
[3] (Pratt et al., 2011)
[4] See www.usgbc.org/about/history
[5] (USGBC, 2019)
[6] (Walsman et al., 2014)

The hotel samples for this research were chosen from different areas of the world, to represent opposite climate conditions:

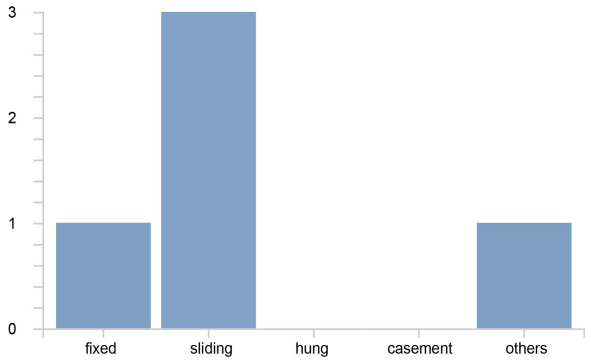
- The Mediterranean Sea
- Upstate New York surrounding Ithaca

The survey text is common for all the sampled hotels, concerning a standard double room, that has been scanned through 25 questions to sum up and verify the 11 parameters that represent the IEQ (Indoor Environmental Quality). The 25 questions asked were regrouped in 5 main groups:

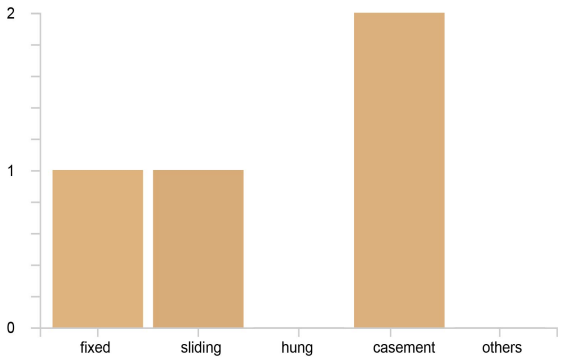
- **General information:** - How many rooms has the hotel? - What is the category of the hotel? – How many square metres approximately has the room? – How many people can stay in it?
- **Windows:** - Does the client have the possibility to open the window and get fresh air? - Type of window installed in the room – Type of glass installed on the window – Type of frame installed on the window – Approximate dimension of the window – Does the room have a clerestory window installed?
- **Natural and artificial lighting:** - May the customer change the light intensity in the room? - Does the room have an occupancy sensor to switch on or off the lights? – Does the room have light shelves on the façade? – Which kind of adjustable window shades has the room?
- **IAQ and HVAC systems:** - Is it allowed to smoke into the room? – Has the Hotel installed an HVAC equipment? - Which is the furniture installed over the windows? – Does the room have a thermostat that allows the customer to change the temperature in their immediate environment? – Does the room have an adjustable air diffuser that allows customer adjusting the airflow?
- **Façade and external environment:** - Which is the orientation of the main façade of the room chosen? – Has the room a rooftop solar water heating system? – Has the room a balcony or a terrace? – Has the room a pool in front of the room? – Has the room vegetation/flora in its immediate environment? – What visual connection has the customer outside the room?

3. RESULTS

The survey analysed 9 facilities including one economy, three mid-range (3 stars) and 5 deluxe (5 stars) hotels. The buildings have on average 72 rooms each, with a minimum of 9 rooms in a three-star hotel on American soil and with a maximum of 149 rooms found in a five-star hotel in Europe. The rooms usually range around 30 square metres, the only exceptions being a three-star hotel in the USA with a room of 20 square metres, and two luxury hotels in the Mediterranean having a floor plan of, respectively, 80 and 137 square metres each. Three of the rooms analysed are to be used by two customers, three of them by four adults and a baby, one by three adults and two babies and two hotels chose not to answer this question.



[Graph 1] American hotels window type



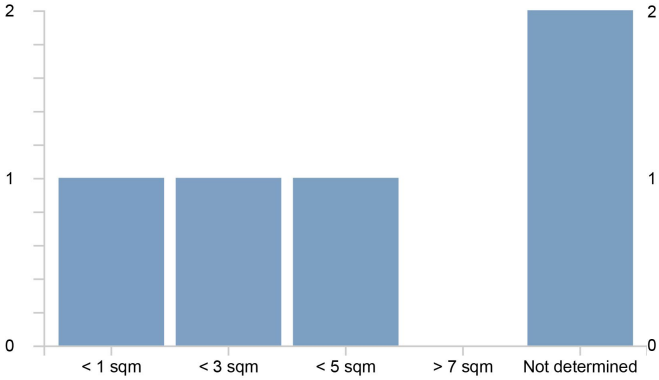
[Graph 2] European hotels window type

3.1. Windows

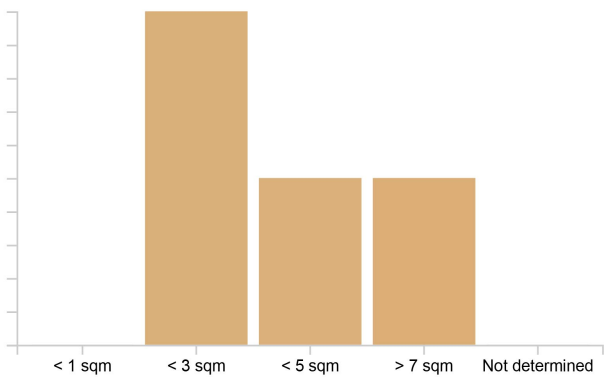
Three hotels in America and one in Europe present sliding windows, two hotels in Europe have a casement window, one in Europe and one in America have a fixed window, and another American hotel would rather not answer that question (see graphs 1-2). We can therefore see that in America the sliding windows are the ones usually chosen as in Europe casement windows are vastly more in use, probably due to climatic issues:

- casement windows let fresh air flow in the room more easily in summer months,
- sliding windows offer a better control of the air flow in colder environments;

All of the windows have clear glass, usually them being single or double glazed in American hotels and high performance double glazed or triple glazed glasses in European hotels, giving therefore to Mediterranean hotels a better control over outside environmental factors.
Five out of nine window frames are made in aluminium, being a light and efficient material, two (one in Europe and one in America) are made in wood and just one American economy hotel has them done in vinyl, that choice being probably made for economic and insulation factors.



[Graph 3] American hotels window dimension



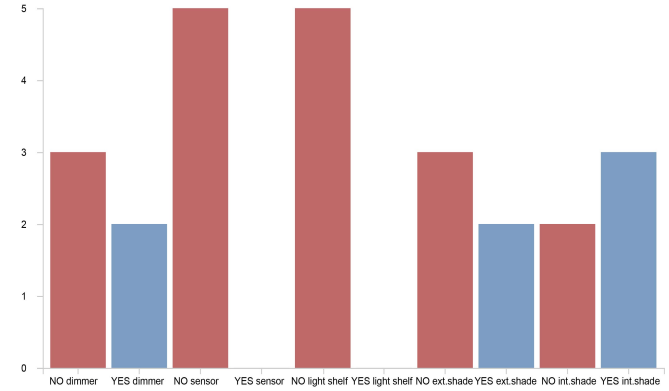
[Graph 4] European hotels window dimension

The window dimensions range from 100 by 50 cm to 190 by 170 cm in American hotels, while in the European ones they range from 180 by 120 cm to 225 by 350 cm (see graphs 3-4); this difference in dimensions is due to climatic reasons:

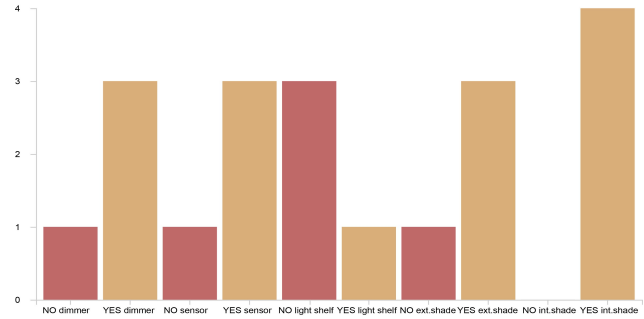
- smaller windows in fact result in a minor area of the room exposed to outside weather and climatic conditions
- bigger windows allow for a much freer airflow and an increased exposure to natural sunlight.

None of the American hotels has clerestory windows, while two out of four European hotels have them in some rooms.

3.2. Natural and artificial lighting



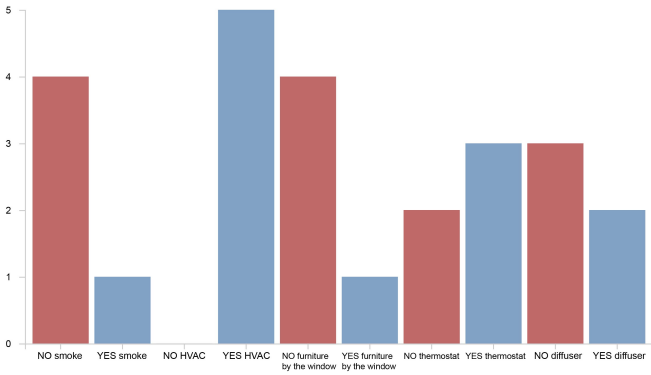
[Graph 5] American hotels lighting



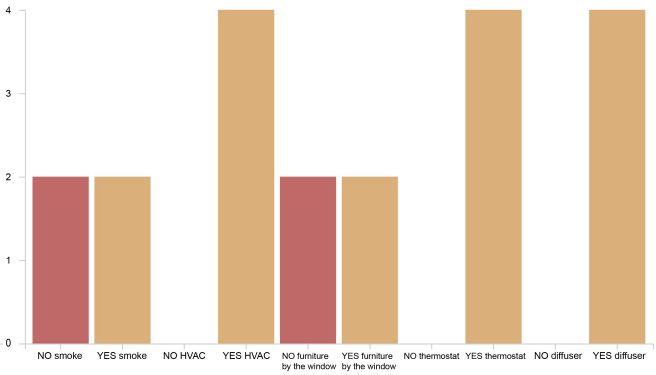
[Graph 6] European hotels lighting

If we analyse the artificial illumination we can see that just two hotels in America and two in Europe have the possibility of varying the light intensity in the room, and that no American hotels have an occupancy sensor for switching off lights when the client is out of the room, while that practice is well established in Mediterranean hotels: just one out of four of them doesn't have an occupancy sensor, two of them have one and one of them has a key-card holder that works as the main switch for the lights in the room (see graphs 5-6);
Analysing instead the amount of natural lighting entering the room, we can observe how just one of the European hotels and none of the American ones have light shelves on the façade for a better light penetration and solar access in the room. Another parameter worth considering for the natural lighting is the type of light shades available in the rooms: two out of five hotels on American soil have an adjustable outside window shade, and two out of five of them have an interior one. Instead, all of the European ones have an interior shade and three out of four of them also have an adjustable exterior one, resulting in an increased visual comfort (see graphs 5-6).

3.3. HVAC systems and IAQ



[Graph 7] American hotels HVAC/IAQ

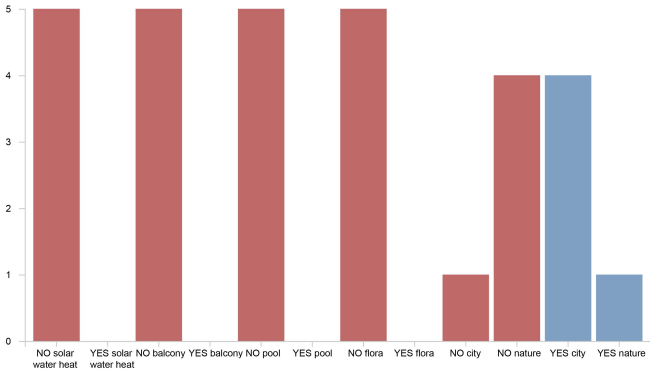


[Graph 8] European hotels HVAC/IAQ

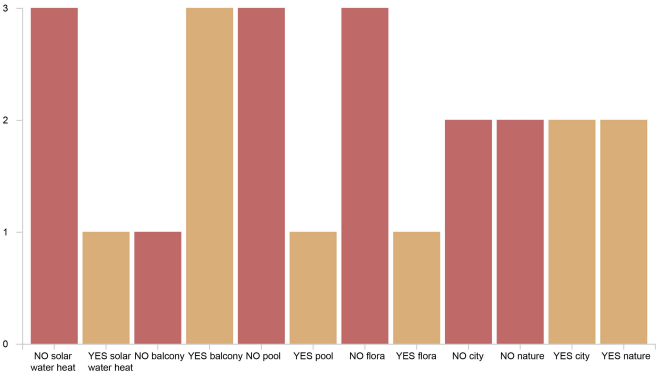
In six out of nine of the rooms analysed by the survey, smoking inside the room is not allowed: in fact just one of the given hotels in the USA and one in Europe allow their clients to smoke in all of the rooms and one European one in some of the rooms; tobacco smoke, and its negative impact on IAQ, is therefore more accepted in indoor spaces in the Mediterranean than in the American ones;
All of the rooms taken into consideration present an HVAC system (see graphs 7-8).

Regarding the possibility to adjust the temperature in the room, only two mid-range hotels in America haven't got the possibility to adjust it through a thermostat, while in Europe all the hotels allow it; same thing applies for the air diffusers, where all the European hotels display one and three out of five American hotels don't have the possibility to adjust the airflow in the room (see graphs 7-8)
One out of five American Hotels and two out of four European hotels have the HVAC system placed close to the windows, resulting in a greater thermic dispersion in the Mediterranean Area.

3.4. Façade and external environment



[Graph 9] American hotels façade and exterior



[Graph 10] European hotels façade and exterior

The orientation of the facades of the hotel buildings considered vary vastly, with two hotel rooms facing north, two south, two south east, one west and one northeast: it is therefore not possible to find a design pattern nor in Europe nor in northern America based on the orientation of the buildings and their consequent solar exposition, that could result in a more efficient temperature, IAQ and natural light control.
Furthermore, only the European hotels have balconies: two out of four of them have an uncovered balcony and one has a covered one, while the American hotels considered don't have any, and just one among the European hotels and none of the American ones has a rooftop solar water heating system, a pool in front of the room and some vegetation around it (see graphs 9-10).

The visual connection outside of the room is also an element of interest:

- four out of five of the American hotels have as a first impact the surrounding city,
- two out of four European hotels also have as a first impact the surrounding city;
- natural elements outside one room in America are the hotel private garden and facilities,
- natural elements outside two of the Europeans room are the sea and the hotel private garden, those hotels having also the pool in one case and other facilities like the Spa or the gym in another (see graphs 9-10).

We can therefore see how different the emotional impact would be in the occupants of those rooms, as in the hotels with an outside view on the garden or other natural element the effect on the customer is a relaxing one, as it is safe to assume that the purpose of their trip is a leisure or holiday one.
Instead the effect on the customers with a room on the city would be not a relaxing one, but an exciting one, as a built environment could create a state of psychological arousal on the occupants, that is safe to assume could be business travellers.

4. CONCLUSION

The research highlighted the consequent differences between the two geographic areas.
In Europe:

- windows appear to be bigger and more easily opened, to take advantage of the natural ventilation thanks to the mild weather, though also causing thermic dispersion;
- European hotels have power consumption reduction systems put in place;
- all the rooms have an HVAC system, presumably focused on the refrigeration due to the high temperatures in summer. Smoking is better tolerated than in America, resulting in a lower IAQ.
- Most hotels are located in vacation places, so the environment suggests relaxation and leisure. Only the European hotels have balconies.

In America:

- windows are smaller than the European ones to keep the warm temperature inside the room;
- American hotels do not have any electric power consumption reduction systems in place;
- as the European ones, the American rooms are all supplied with an HVAC system, in this case focused on the heating, but with a limited possibility to adjust temperature and air diffusion; smoking inside is less tolerated, resulting in better IAQ.
- Many of the surveyed American hotels are located in the city, so the views don't have the same relaxing features found in the Mediterranean Sea, but instead a more exciting one.

4.1. Limitations

The survey was completed on a restricted number of hotels, the same methodology could be applied on a broader sample of hotels for more uniform and complete results. Further considerations on the maintenance and on the life cycle of the furniture and objects found in the room could also be applied to evaluate the IEQ.

5. ACKNOWLEDGMENT

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