Contribution to improving the energy performance of a hotel in Tangier - Morocco

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Overview

Morocco, very weakly endowed with conventional energy resources, highly dependent on the outside for its energy supply. This Energy dependence is thus estimated at 93.61% in 2013 [1]. Furthermore, annual energy consumption per capita increased from 0.30 toe per capita in 1990 to 0.55 toe per capita in 2016 [2]. The transport and building sectors are the biggest energy consumers in Morocco and together account for more than 60% of total final energy consumption [1]. As well as**,** the building sector accounts for 33% of the country's total energy consumption, of which 25% for the residential sector and 8% for the tertiary sector [1]. Besides, the tourism sector accounts for one third of tertiary sector consumption, due to growth in electricity and air-conditioning consumption. Tourism is one of the major vectors of the Moroccan economy which is destined to gain even more importance to support economic development.

Tourist establishments are considered among the most energy-consuming buildings due to the high energy consumption for lighting, air conditioning, heating and hot water production in order to provide services to customers and guarantee their internal comfort [2]. In fact, air conditioning and lighting in the hotel sector remain highly dominant, accounting for 21% and 20% respectively, followed by the production of domestic hot water which represents 17%, the rest of the energy consumption distributed between the heating (14%), kitchens (12%) laundries (6%) and others (10%)**.** In addition, the energy consumption varies considerably between different types of hotels depending on the size of the hotel, the class / category, the number of rooms, the customer profiles, the location, and the types of services / activities. In general, the energy required for a hotel building is intended for thermal energy needs and varies between 40 and 70%, which implies a high energy consumption. In particular, the installation of air conditioning can represent up to 50% of the total energy installations of the building, a poorly designed heating system, where maintenance operations are not carried out, can generate losses in thermal energy of 30 to 40%**.** As a result, improving the competitiveness of the tourism sector requires progressive reduction of operating costs, especially those of major importance, such as energy and water costs. In this context, the HVAC system is the major consumer of energy in commercial buildings, particularly in the hotel sector [3], therefore hotel owners aim to reduce the energy bill in this sector. Besides, energy efficiency measures in the hotel industry include air conditioning systems [3], the thermal performance of the building envelope and the production of water heaters.

In the present study, an energy, environmental and economic study for a hotel building *is carried out specifically to assess the potential in* reducing energy consumption, energy demand, and carbon emissions associated with the hotel building sector. First, a briefly comparative study of two heating and cooling systems (VRV and GRL) is outlined. Then, the passive analysis for assessing the impact of three energy efficiency improvements is described and discussed. Finally, an analysis and comparison of the two energy systems for the production of domestic hot water is studied using an energy, economic and environmental study.

Methods

II.1 Building description

The hotel studied (Figure **1**) located in the business and leisure district of Tangier, the hotel's total surface area amounts to 12508.6 m², it is endowed with a ground floor, a mezzanine and ten floors including 220 rooms in total. The ground floor consists of a wing containing the offices, the reception and the shop, and a wing including the bar, the show cooking and the customer counter. While, the mezzanine has a conference center with a capacity of nearly 100 participants. The different occupancy rates of the zones are fixed as follows 0.055: person/m² for the rooms (Area = 36 m²), 0.6116 person / m² for the conference room (Area =114 m²), 0.107 person / m² for the office (Area = 93 m²).

Figure 1: Hotel of Tangier

The occupancy schedule of a room is shown in Figure 3, The internal heat gains are 0.9 MET (58W/m²) for persons, 323 (W) for Minifreezer, 90 (W) for TV LCD, and 11.9 (W/m²) for lighting appliances. DesignBuilder software, based in the engine EnergyPlus calculation, is used in this study.

II.2 Economic study: Life Cycle Cost Analysis -Method

The financial analysis in this article adopts the life cycle cost method, the life cycle cost (LCC) analysis method is the most commonly accepted to assess the economic benefits of energy conservation projects over their lifetime. Typically, the method is used to evaluate at least two alternatives of a given project. The LCC amount for each alternative can be computed by projecting all the costs (including costs of acquisition, maintenance, and operating the energy systems related to the energy-conservation project). LCC can be estimated based on the initial cost IC and the annual cost AC as follows [55]:

$$LCC = IC + USPW(d, N) \times AC$$

The uniform-series present worth factor (USPW) can be expressed as follows:

$USPW(d, N) = \frac{1-(1+d)^{-N}}{d}$ where N and d are respectively the lifetime and the discount rate.

II.3 Assessment of the HVAC system

The electricity is the main energy source used in heating and air conditioning systems in Moroccan tourist establishments, the average consumption recorded is 2.223.300 kWh/year/hotel. In fact, a better select of air conditioning technologies for hotel establishments can have a significant effect on electrical consumption, also improving environmental performance generally, in consequence reducing operational costs. In this part, we performed a comparative study between two heating and cooling systems, the Variable Refrigerant Volume System (VRV) and chilled water system (CWS) using the Life Cycle Cost method to determine the most economically efficient system for the hotel. First, we calculated the total heating and cooling load using the DesingBuilder software, we obtained a total cooling load of 1234.27 kW and a heating load of 448.96 kW. This amount of information was sufficient to begin the process of sizing these two systems, the sizing of each system is done by the selection of the indoor units and the outdoor units as well as the sizing of the pipes and the choice of accessories. In order to compare the two air-conditioning systems, an economic study is carried out to quantify the investment costs of the systems including maintenance and operating costs.

Results and conclusions

The present study consists firstly to comparing two air conditioning and heating systems for the hotel building. In order to determine the most economical, technologically reliable and least environmentally impacting system. Secondly, to evaluate the energy, economic and environmental performance of the two systems of domestic hot water production of the studied hotel and their combinations with the solar collectors. This analysis shows that the Variable Refrigerant Volume system is the most economical, and the most adopted for the hotel. This choice implies a net investment of 650 000 US$, its environmental pollution is estimated approximately 85548.2 kg-CO_2 annually. Several recent studies have proposed solutions to improve the energy efficiency of the hotel sector, in this work we studied the effect of three improvements on the reduction of hotel needs. 3rd SC of natural ventilation leads to the reduction of energy needs of the hotel is about 27% annual. Then, the 2nd SC of Glazing Film reduces by approximately 36% of the annual needs compared to the basic building. Finally, the cool roof of high reflectance and emissivity coefficients leads to a reduction in annual needs of 28% annually. From the environmental perspective, these three scenarios lead to a reduction of almost 28%, 28% and 35% of CO_2 emissions. It can be noticed that the three improvements have significant energy savings with a life cycle cost slightly lower than that of the standard building, except the second SC of PF which presents a higher LCC compared to these of the building.

It has been observed that the usage of a heat pump as a technology for the production of hot water in the hotel sector results the lowest primary energy consumption, compared to a gas boiler, about 47.5% reduction in annual consumption. Although boiler systems consume more energy than air-source heat pumps, the former produce smaller amounts of CO_2 emissions than the latter 21.2% more CO_2 emissions than the gas boiler. From an economic perspective, the life cycle method for the various technologies, implies that the global savings on energy bills generated by the use of heat pumps will amount to 13110 US$ compared to a boiler. In addition, the payback period of investments for a heat pump combined with a solar installation varies from 3 to 4 years, and it is lower compared to that of a boiler plant combined with solar collectors. As well as, the heat pump and its combination with solar results in high NPW values compared to a combined system with a boiler.

Results and conclusions

[1] https://www.iea.org/statistic,03-03-2018

[2] P.Bohdanowics, A. Churie kallhauge, I.Martinac, Energy Efficiency and conservation in hotels towards sustainble tourism, 4th International Symposium on Asia Pacific Architecture, Hawai'I, April 2001.

[3] M. FadzliHaniff, H. Selamat, R. Yusof , S. Buyamin, F. ShamIsmail, 'Review of HVACscheduling techniq ues for buildings towards energy-efficient and cost-effective operations' Renewable and Sustainable Energy Reviews, 27 (2013) 94-103.