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Development of a concept for energy optimization of existing Greek hotel buildings

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Abstract

Hotel buildings are unique compared to other public, commercial buildings due to their varying size as well as their facilities and operating schedules. Recent studies indicate that hotels are the second highest energy consuming category after hospitals. Even though they represent only 0.82% of the building stock, they reflect 28% of the total final energy use in the tertiary building sector of Greece. The reported average energy consumption for Greek hotels is 273kWh/m^2 annually. Purpose of this Master Thesis was to evaluate different energy optimization scenarios for an existing hotel building as a case study and calculate the potential energy savings using the Greek software TEE-KENAK. Three main subjects were investigated: the building envelope, the electromechanical systems and the application of renewable energy technologies. Based on the results from several simulations, it is concluded that it is possible to reach an average reduction of 60% in the annual primary energy consumption.

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Keywords: energy retrofitting; greek hotels; renewable energies; sustainable architecture

1. Introduction

Tourism is one of the main sectors of the Greek economy that motivates regional and national development and still offers employment opportunities. In 2012 the international arrivals reached 15.5 million people leading Greece to the 17th place in the World Rankings, while in 2015 the total number exceeded 25 million [1]. According to the National Statistical Agency of Greece in 2011 there were 9732 hotel units with 32806 buildings out of approximately 3.5 million buildings reflecting the 0.82% of the building stock. In the last twenty years an increase of more than 50% in the hotel units has been reported. This development follows a steady trend and has an average

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annual growth of 1.9% [2]. Since 2012 the hotel capacity of the country is growing, while the average size of hotels in Greece continues to increase. The figures mentioned above emphasize in consequence the role of the touristic sector in Greece as an essential tool not only for the national economy but also for the regional development.

Nowadays buildings are responsible for 40% of energy consumption in the European Union while about 35% of the building stock is over 50 years old. Hotel facilities rank among the top five in terms of energy consumption in the tertiary building sector (minor only to health care and certain types of offices) as a result of their unique operational characteristics and nature of their occupants. Recent studies show that the average energy consumption for Greek hotels is 273kWh/m^2 annually [3]. Quite interesting is that in Europe the estimated total energy consumption of hotels accounted approximately to 0.7 to 1% of the final energy consumption of buildings, while in Greece it was 4.3 - 5% for the years 2007 – 2010 [4]. Moreover these numbers reflect 28% of the total final energy use in the tertiary building sector of Greece, although hotels represent only a very small part of the building stock.

In order to identify the most suitable retrofitting actions and assess their effectiveness an existing hotel building was selected as an exemplary project. The range of investigation was focused on Macedonia region, which has about 15% of the hotel units –the third biggest concentration after Crete and Dodecanese– and presents the second coldest climate conditions in Greece with direct influence on the energy consumptions. The city of Thessaloniki was selected, a popular destination all over the year and the second biggest city of Greece with 1100000 inhabitants [Census 2011]. A survey of the current hotel facilities was initiated in order to identify the characteristics that the exemplary building should fulfill.

Following the survey's results and the available literature data [5,6] a five-star hotel was studied. It is an 8-storey building, constructed in 1968. In 2001 the building went under a renovation of the plumbic networks but no further interventions have been made. The hotel's area is about 9032m^2 with a typical floor of 1002m^2. It has a capacity of 335 beds and features three different types of rooms with a total of 176. The facilities are open all year round 24hours a day and the demand for electric and thermal loads are also 24/7. On the ground floor there is a restaurant and dining room of 225m^2 together with the kitchen facilities and storage rooms. Regarding the building envelope the bearing structure is made of reinforced concrete and the external walls are from brickwork. The building components are insulated, but having been built before 1980 the insulation should be considered as inadequate. All the windows and balconies' doors are double glazed with aluminum frames. The hotel has a central heating system with gas connected to fan-coils. This central heating system covers also the hot water needs for washing, showering and cooking. In the summer the fan-coils are responsible for cooling using electricity, while their operation is controlled manually in each room. All rooms are naturally ventilated via the openings and no mechanical ventilation is installed. The building has a rectangular layout with the biggest glazed facades facing southwest (main entrance), northwest and southeast. Almost all the facades are exposed, despite the dense construction of the city center. The rooms located on the 1st - 8th floor are distributed to the facades, whereas long corridors facilitate the circulation. Interesting is the impact of the solar gains into the hotel rooms, as the main facades receive significant amount of solar radiation throughout the whole year.

2. Energy consumption of the exemplary building

The energy behavior of the selected hotel was simulated using the Greek software TEE-KENAK. The software has been created by the Institute for Environmental Research and Sustainable Development of the National Observatory of Athens in-between the framework of cooperation with the Technical Chamber of Greece. For the calculations the data on the geometrical and technical characteristics of the building envelope have been imported into the software together with the information of the existing electromechanical installations.

As the actual operating conditions can vary depending on the use and the users of each building, the Technical Guideline (TOTEE 20701-1/2010) [7] of the Regulation on the Energy Assessment of Buildings defines specific values on national level for the operating conditions of the examined building in accordance to the European standards.

Each examined building is divided in thermal zones, namely areas with similar function, operational profile and/or electromechanical equipment. This division should result to the smallest possible number of zones in order to achieve a smaller amount of input data and less time-consuming calculations.