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Modeling energy consumption and efficiency measures in the Italian hotel sector

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ABSTRACT

Energy efficiency is one of the main pillars of the European energy strategy and it involves all the economic sectors. The present study proposes an analysis of the energy saving opportunities available in the Italian hotel sector, which has a relevant importance in the national context. The paper introduces a comprehensive model of the Italian hotel sector developed in the LEAP (Long-range Energy Alternatives Planning) environment. The first aim is to estimate the baseline of the consumption, then to evaluate the maximum potential energy saving and, finally, to assess the implementation of a realistic energy efficiency scenario. The paper demonstrates that it may be possible to achieve primary energy savings of 1.6 TWh (13%) in 2030 by implementing financially sustainable energy efficiency measures.

1. Introduction

In 2014 Italy resulted to be the third European touristic destination, after Spain and Germany, in terms of presences in hotels and similar accommodations [1]. The hotel sector is of fundamental importance for the Italian economy, since tourism contributes to a substantial share of the national Gross Domestic Product (GDP), 10.2% of the GDP in 2015, and it is relevant also at international level, because 16.5% of EU hotels is located in Italy [2].

Since hotels offer a large range of services to their clients, they are among the highest energy consumption building types, as shown in previous studies [3,4]. Therefore it is central to evaluate the possible energy efficiency potential of this particular class of buildings.

Different authors studied energy consumption in hotels, as well as their carbon footprint, by employing different methodologies and analyzing different aspects of the problem.

Mavrotas et al. [5] presented a linear programming model to optimize energy consumption in a large hotel located in Greece. They took into account different energy technologies and fuel cost, including the uncertainties connected with fuel market. Accordingly, Taylor et al. [6] performed a detailed simulation model of two hotels in UK and studied the effects of energy efficiency measures ready available and accessible in the near future, in order to estimate the energy saving potential in 2030.

Other authors proposed more systemic studies by analyzing the hotel sector in general or by considering groups of hotels. In this respect, Xuchao et al. [7] studied the hotel sector in Singapore. In particular, they performed a statistical analysis on energy and environmental data collected on the field and implemented a regression based benchmarking model. Similarly, Lai [8] developed a statistical analysis on four and five stars hotels in Hong Kong, in order to understand the correlation between energy consumption and maintenance costs and he observed that between the two considered hotel typologies there are not large differences. Tsai et al. [9], instead, focused on the carbon footprint of different hotel categories in Taiwan. They concluded that the accommodation of more tourists in the low carbon emission structures will allow obtaining a substantial reduction of carbon emissions without reducing the total number of guests.

Similarly, Wang and Huang [10] developed a study on the correlation between country of origin of customers, energy consumption and hotel revenues in Taiwan. They observe that guests from the well developed countries generally create more revenues. However, additional expenses on energy will also incur for hotels whose marketing preference is towards them. In profit-energy costs perspective, they conclude that hotel targeted for guests from Japan might be the most beneficial in Taiwan. Following a similar path, Oluseyi et al. [11] proposed an analysis of the energy consumption and carbon footprint of hotels in the city of Lagos. They developed a correlation analysis and found that the energy consumption per unit guest room and the carbon dioxide emission level are closely related.

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Other authors enlarged the boundaries of their analysis to the whole tourism sector, as is the case of Logar and van den Bergh [12], who studied the impact of the peak oil on tourism sector in Spain. Their estimations show that a substantial increase of the oil price will largely affect the Spanish tourism sector by provoking a relevant decrease of the arrivals with negative impacts on the county economy.

Another approach for energy system modelling, largely utilized in the literature, is the development of bottom-up models, in order to analyze the processes which lead to energy consumption in a specific sector. In this way it is possible to understand in detail which are the sources of consumption, but, on the other hand, the amount of data necessary to calibrate such models is relevant.

By utilizing this approach, Ozer et al. [13] modelled the Turkish electricity sector with the aim to estimate the CO_2 reduction potential in the long term. They implemented their model by using the LEAP platform. LEAP is an energy-environment modelling tool developed at Stockholm Environment Institute, Boston (SEI-B) to assess the

physical, economic and environmental effects of alternative energy programs, technologies and other energy initiatives [14].

It is a very popular platform to simulate energy systems and many applications can be found in the literature. For example, Gomez et al. [15] employed LEAP for the simulation of the Spanish power sector. They analyzed the impact of the absence of energy planning in the Spanish power sector by proposing the assessment of different scenarios. Similarly, Rahman et al. [16] utilized the tool to study the power sector in Bangladesh.

Other researchers utilized the software to study sector other than power. For example, Peng et al. [17] employed LEAP platform to develop the energy and environmental model of the transportation sector of the city of Tianjin in China. They assessed the effects of different scenarios in terms of primary energy consumption and pollutants emission. Instead, Ates [18] modelled the iron and steel industries by using LEAP with the aim to analyze the energy efficiency potential and the mitigation of carbon emissions.

As previously mentioned, given the strategic importance and the consistence of the hotel sector in Italy, the aim of the present paper is to build an energy model for this sector. The model is developed by using the LEAP platform. According to the literature review, LEAP can be considered as a flexible and powerful platform for the simulation of energy systems. The Italian hotel sector is modelled (LEAP-IHS) by taking into account the different categories of the structures with the corresponding appliances available in different categories of hotels. Once obtained and validated the Business As Usual (BAU) case, two different scenarios are considered, namely Best Available Technology (BAT) scenario and Realistic (REA) scenario. The aim of testing these two scenarios is to estimate the maximum potential for energy savings and emissions reductions (i.e. BAT scenario) of the Italian hotel sector, as well as a realistic estimation of achievable results in short-medium period (i.e. REA scenario).

To the best of authors' knowledge, the present study represents the first attempt available in the open literature of modelling the Italian hotel sector.

2. Snapshot of the italian hotel sector

In 2014, Italy was the third country, after Germany and UK, in terms of number of hotels and similar activities (e.g. Bed and Breakfast) within EU, whereas it represented the first country in terms of available bed places, accounting for the 16.4% of the EU [1].

According to the Italian law, hospitality structures are divided in hotels, grouped in five categories from one to five stars, and other hospitality structures. Table 1 shows the consistency of the different kind of structures and hotels categories. By analyzing the data reported in the table, it is possible to determine that, approximately two thirds of the structures is represented by two and three stars hotels, whereas 77% of the beds is concentrated in three and four stars hotels. In terms of rooms per structure, one star hotels represent the category with the smallest number, whereas four and five stars hotels have substantially higher number of rooms with respect to the other categories.

Table 1
Hospitality structures in Italy for typology and category [19].

Structure	Number	Rooms	Beds	Rooms per Structure
5 Stars Hotel	393	29645	64106	75
4 Stars Hotel	5354	349701	736311	65
3 Stars Hotel	15243	480438	962662	31
2 Stars Hotel	6509	110327	209944	17
1 Star Hotel	3438	43455	80606	13
Other	2791	79729	197075	29
Total	33728	1093286	2250704	

Table 2
Minimum requirements of rooms in relation to the assigned category [20].

	1 Star	2 Star	3 Star	4 Star	5 Star
Single Room	8 m^2	8 m^2	8 m^2	9 m^2	9 m^2
Double Room	14 m^2	14 m^2	14 m^2	15 m^2	16 m^2
Per each added bed	6 m^2	6 m^2	6 m^2	6 m^2	6 m^2
Bathroom	3 m^2	3 m^2	3 m^2	4 m^2	5 m^2
Share of rooms with bathroom	40%	80%	100%	100%	100%
Air conditioning				Yes	Yes
Minibar				Yes	Yes

Table 3
Specific energy consumption/thermal characteristics of Italian hotels [21].

Typology of consumption	Value	Unit of Measure
Yearly energy consumption for winter heating	2.5–3.5	MWh/room
Yearly energy consumption for hot sanitary water	3.8–4.4	MWh/room
Yearly energy consumption for summer air conditioning	1.0–3.5	MWh/room
Yearly Electricity Consumption	5.0–11.0	MWh/room
Average transmittance of walls	1.4	W/(m^2K)
Average transmittance of windows	4.0	W/(m^2K)

Hotels are assigned to a specific categories, according to the prescriptions of the Italian Decree 21/10/2008 [20], which establishes, in terms of minimum dimensions of the rooms and available services, the basic requirements to be assigned to a specific category, as reported in Table 2.

The presence of other services is regulated on the basis of regional laws, but, in average, it can be said that for 3–5 stars hotels television is obligatory in all the rooms, a bar should be included in the structure, whereas the presence of a restaurant is obligatory only for four and five stars hotels.

Due to the different dimension of the rooms and level of available services for the different hotel categories, it is expected that energy consumption in higher level hotels will be higher with respect to lower categories.

Data concerning energy consumption in the Italian hotel sector are reported in [21], which shows the results of a statistical survey aimed at the energy characterization of a significant number of Italian hotels. It reports specific energy consumption in different end users activities, as shown in Table 3. It is to be highlighted that despite the importance of the Italian hotel sector in terms of energy consumption, the work reported in [21] represents the only systematic contribution to the topic. At moment, there are no offi-