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Intelligent Energy Consumption in the Balearic Islands Hotels

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Abstract. Hotels, in which belong to the tertiary building sector, rank among the highest in the energy consumption sectors. The Balearic Islands are a representative example of tourist islands, with more than 2.500 Hotel and touristic industries, which implies with its approximately a half million available beds, an increase in 50% of the population at high season. High energy consumption in hours with low Renewable energy production are additional problems in this case. From the information of 250 Hotels were studied in order to investigate the levels of energy consumption and sustainability among them with future zero emissions scenarios. This paper analyses available information concerning energy consumption in hotels, with a focus on Electric demand (most of them from HVAC systems). The aim is to determine a model for predict the energy consumption, and coupling it as much as possible, to the RES of energy demand. For arrive to this goal smart buildings can foster energy efficiency and tackle the reduction of CO_2 emissions within the atmosphere. The Hotels can guarantee good lighting, ventilation, cooling rates, along with other aspects of building demands in real-time. Monitoring and sensing combined solutions with simple and efficient methods are the protagonists of advanced sustainable building technology, for instance, the implementation of smart strategies such as thermal storage or pumping systems..

Keywords. Energy Audits, Hotel, Energy Efficiency (EE), Renewable Energy Source (RES), Smart Energy

1. Introduction

Climate change is a fact, and the actual situation is a world emergency and the buildings have to reduce the CO_2 emissions. Balearic Government have approved a plan to decarbonize the islands in 2050 with 100% of renewable energy for the electric production.

Nowadays, energy efficiency in buildings is a prime objective for energy policy at regional, national and international levels, especially in Europe where many new policies have been applied.in application. Energy consumption in hotels is amongst the highest in the non-residential building sector in absolute values (an average of 150 kWh/m^2) [9]. The difference lies on the efficiency processes and the unitary consumption of the users (especially in thermal necessities when considering the

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diverse external temperatures and the divergent comfort temperature between native dwellers and visiting tourists).

Considering the fact that a building's operational costs will grow with time and that problems only get worse unless some actions are taken, there is a clear need for proper building maintenance, refurbishment or retrofitting (upgrading). Such actions should focus on the building's structural elements and installations, which can also improve energy performance and indoor environmental quality.

The hotel sector is uniquely placed to provide the impetus for change in business behavior within tourism, because of its multiplier effect on guests, staff and suppliers, as well as the central role that hotels play within local communities. Additionally, possible energy conservation techniques for RUE and exploitation of RES have a unique demonstration potential and a high exposure to millions of people that visit hotels at one time or another.

Hotels are usually located in areas with high seasonal energy loads, and frequently with high energy cost and low supply (i.e. islands).

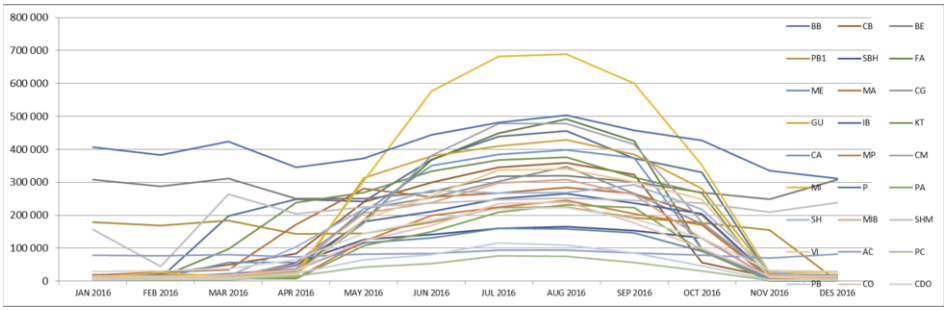

Figure 1. Monthly Energy consumption of different Hotels in Balearic Islands kWh.

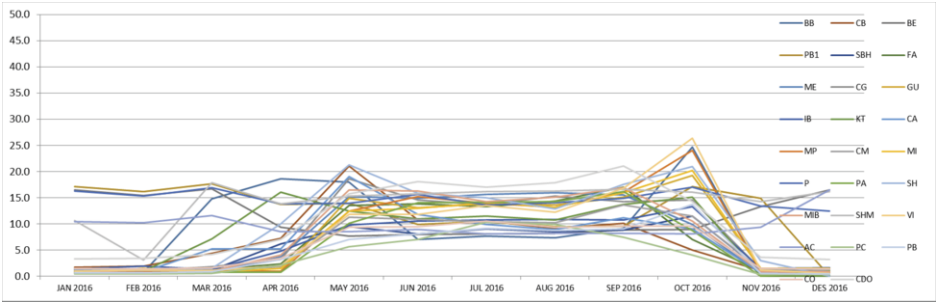

Figure 2. Monthly Unitary Energy consumption of different Hotels in Balearic Islands in kWh/m2, kWh/n.s. or kWh/HDD kWh/CDD

2. Objectives

The objectives of the present article are to first find out models for the energy consumption in the Hotels and second integrate renewable energy in order to arrive a real zero CO_2 emissions. The information derived from the energy consumption curves of an area and the temporally consumption of the larger energy consumption sectors of the same area can provide us with a first approach to understand the problems and the possible technical solutions. An in depth analysis of a significant number of energy audits of different industries and buildings can provide us with the necessary information needed for an extrapolation of the energy demand. Furthermore, this will shed light for new ways for energy saving and integration of RES.

For tourist areas, the biggest energy consumer is the tertiary building sector, and especially hotels. However, they usually have a centralized energy production which makes this analysis easier. Energy audits can help hotel companies find out energy management problems and improve energy efficiency, as well as indicating to the government the adequate energy policies to apply .

3. Case study. Balearic Islands

The tourist industry is amongst the most dynamic areas within the services sector, and this is especially the case in Southern Europe (France, Greece, Italy, Spain and Portugal) [9]. The Balearic Islands have historically been one of the primary tourist destinations; there are about half a million beds available, and it is the first destination for Spain. Many successful hotel companies that have emerged during the last few years are now exporting their experience to other expanding destinations.
However, one problem of the Balearic Islands energy model is that it is based on imported fossil fuels [2], only the 3% of the energy is from RES.

The Balearic's Islands over the last 7 years, there has been a decrease in the electrical energy consumption a 0,1%, with a 69% of increase of the Transport consumption with the Electrical Vehicle and Electrical Train. The global contribution of buildings towards energy consumption, residential has steadily increased, reaching figures between 4% (from 1999 to 2009 was a 50%) and the Tertiary sector has decreased 1% where the hotels are included.

Table 1. Sector Annual Electric cons. in the Balearic Is. (Tep)

Sector	Electric Consumption 2009 [tep]	Electric Consumption 2017 [tep]
Industry	25 310	18 629
Tertiary	244730	242 351
Residential	198000	205 524
Primary	7 300	8 085
Transport	90	152
Total	475 430	474 741

3.1. Hotels

The Balearic Government, over the years has performed more than 200 energy audits for hotels within the archipelago. These audits represent 10% of all hotel buildings, and their usage sums up to more than 12 million of nights spend.

The objective of these energy audits is to examine the energy management by the hotel owner and to find out occasional tactics that can improve the energy efficiency by the installation of renewable energy sources (RES). From these audits we discern that electric energy most used in the Islands' hotels, and it is present in all of the hotels. The unitary energy consumption per night spend changes a lot depending on various factors; facilities provided, category of hotel, occupancy, geographical situation, weather conditions, nationality of clients (habits), architecture of the building, design and control of the installations, among others.

With the increase in standard of living, services that were considered as luxurious now are included in the basic services, as the hotels have improved the buildings and they have increase the facilities, like SPA and acclimatized pools. It is hard to convince hotel owners that even if solar energy or heat recovery systems were used only for heating water that this amount to a saving of more than the 18% of the total energy consumption, as well as a saving in this energy cost, amounts, and a reduction in CO_2 of about one kilogram per night spent.

From these audits, we discern that the energy more used in the Islands´ hotels is the electric, owing to 54% of the total energy consumption, while gas and diesel are not used in all the hotels. The factors for predict the energy consumption are de Cooling Degree Days, Heating Degree Days and number of Night Spend.

The most important factors that until now with the most influence on the unitary consumption are: the HVAC service and the occupancy.

Table 2 . Resume of some Balearic Islands Hotels Energy Audits. Correlation Index per night spend or HDD/CDD. Index. Source[2]. Years 2010-2018

Hotel	**R^2**	**Methodolgy**
BB	0.91	NS
CB	0.89	NS
BE	0.80	HDD
PB1	0.86	NS
SBH	0.85	NS
FA	0.93	NS
ME	0.92	NS

MA	0.72	NS.
CG	0.81	NS
GU	0.88	NS
IB	0.95	NS
KT	0.75	NS
CA	0.87	NS
MP	0.81	NS
CM	0.91	NS
MI	0.96	NS
P	0.66	HDD
PA	0.93	NS
SH	0.76	NS
MIB	0.92	NS
SHM	0.95	HDD
VI	0.75	NS
AC	0.83	HDD
CDO	0.95	NS
MM	0.65	NS

However, there are a high correlation in most of the hotels for predict the energy consumption. The highest use of electricity is destined principally for air conditioning which makes the energy consumption per night spend vary during the year, this consumption could be easy stored in buffer tanks and used to make an intelligent control.

3.2. Electric System

A problem in the Mallorca-Menorca electric system, and in the rest of the Spanish Islands, is that its energy model is based on imported fossil fuels. The solar and wind energy they only have the 1 % of the total energy production. The Mallorca-Menorca system has been connected to the mainland with 2 submarine cables 250 kV High Voltage Direct Current (HVDC) with a maximum power capacity of 400 MW, covering a total distance of 250 km in 2012. Actually this provides about 30% of the

energy [2], there is a future project to increase the cable for increase the power, but it's not approved yet. Balearic Island's with an installed power of 2490 MW and 80 MWp of PV installed, 20 MWp of Waste power plant, 3 MWp of wind power and peak consumption of 1205 MW [2]. The main generation system is composed of two thermal power plants responsible for, respectively, 72% and the 12% of the demand on each of the two island subdivisions, and a combined cycle central that started to use natural gas five years ago, in order to reduce the CO_2 emissions and increase the efficiency. The rest is generated in 4 small distributed generation plants. The principal thermal power plant, with a nominal power of 510 MW, constitutes the basis of the system; it's still working with coal, the most contaminant fossil fuel. The other Power Plants assume the peaks of demand in the islands. The described production model produces a high amount of CO_2 emissions, because it is based on coal turbines. The use of coal as fuel also has an important effect, in the production of acid rain. Actually the PV produces some hours only the 10%, with annual production of 2%. The government's Energy Planning Project intends to reduce global energy consumption by 3%, and increase by 35% the use of Renewable Energy Sources (RES) at 2030 and to 100% in 2050. In 2050 will be needed 20 times more of PV, that will be necessary to storage or make intelligent most of the buildings.

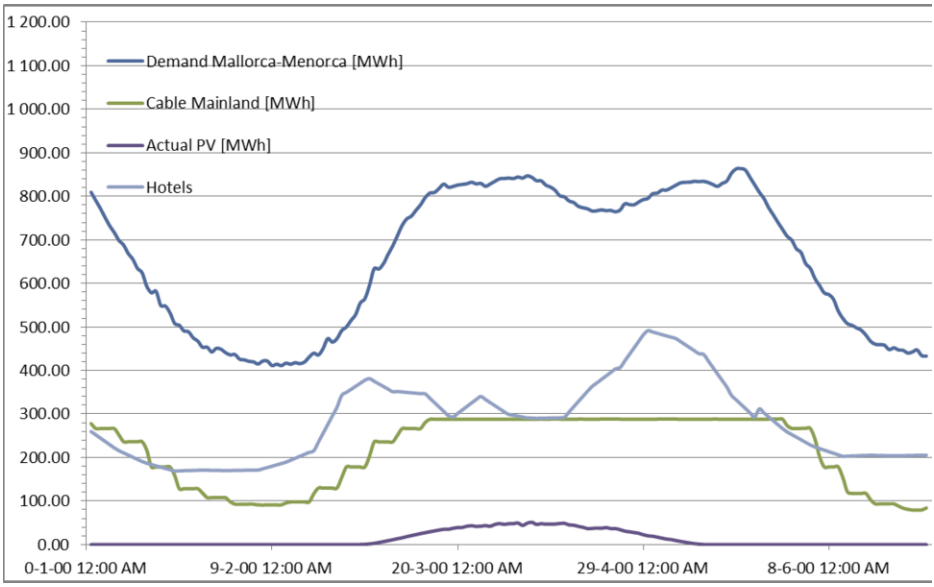

Figure 3. Electric consumption-production and Hotels estimation consumption , August 2016 [10].

3.3. Intelligent Electric Consumption

There are a lot of studies and software that have calculated the energy savings and feasibility of the incorporation of systems exploiting RES and the adoption of techniques intelligent energy use for different tourist areas and countries. The main solutions are the improvement of the efficiency process of the system technology and the management of these systems. Differences as well exist among hotels within the

same category and facilities, depending on the installation design, technology, maintenance and control. This difference in terms of energy consumption between an environmentally friendly hotel that has implemented measures to preserve natural resources and a hotel built during the 1970s and 1980s and not yet refurbished can be from 30% to 60% with all other factors being equal (same climate, same needs).

Future scenarios go from reduction of energy and increase the renewable energies. Mallorca have actually facilities of solar, wind and wastes, and a big potential in hydro, biomass and shallow geothermal. Smart Energy measures in hotels have to be carefully selected in order not to endanger the Electric system and increase the maximum Renewable energy in the system. The highest energy demand in hotels comes from HVAC devices, raising the demand of electricity which is the common source of energy in all hotels and the easiest to save and to store with buffer tanks.

Accordingly, priority should be given to control energy used in the guests' rooms, for example, by using simple controls to ensure that practically all electrical appliances are turned off when guest rooms and corridors are unoccupied. A better distribution of the building's layout and an improved control of energy use result to a potential energy saving between 15 to 30%. The total energy consumption for hot water may represent between 12%-36% of the total energy consumption, which varies according to the hotel category and weather conditions. Average annual energy consumption may reach 1300-5000 kWh per bed. Installing between 1-2 kWp per bed we could arrive to a sustainable scenario.

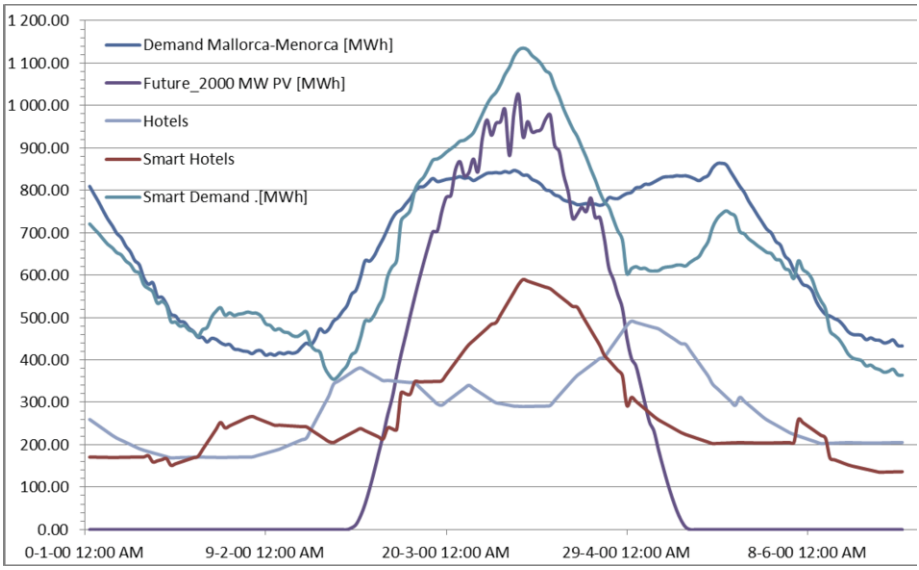

Figure 4. Estimation of Electric consumption-production , August 2050

The potential average annual energy savings from solar collectors reach 1200 kWh/kWp [9]. Thus they can be used to cover a significant part of the energy demand (80%), and if combined with smart chillers, they can also be used for cooling. The use of heat recovery from the cooling system (i.e. the recovery of waste heat from cooling

towers as useful energy) can also be used to adjust the consumption to the PV production, thermal energy could be stored and adjust the swimming pool depuration system.

4. Conclusion

Applying a smart systems and RES to the hotels can result in a large economic, energetic saving and a reduction in CO_2 emissions without change in client comfort and increase the RES integration, especially the Solar PV systems. By changing from fossil fuels for renewable energy sources (like photovoltaic, wind power and solar thermal), we can arrive at zero or even negative building energy. Promoting and investing on renewable energies to combat CO_2 emissions is the way to stop to discharge more than 50,000 tons per year with a properly electric mix. The overall zero balance in the Mallorca-Menorca system is overall positive in the order to cover Tertiary sector consumption.

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