Evaluation of the Renewable Energy application in Mediterranean Hotels: Case study: the Balearic Islands` Hotels

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Abstract.

The strategic changes in the energy management are usually increased after petrol crisis or policy changes. The Kyoto protocol and the increase of fossil fuel price make necessary a deep change in the design and the management of the energy facilities. Spain in general is living now these big changes, and there is an upsurge of installation of renewable energy sources.
Hotels are high energy consumers in the tertiary building sector. Improved service quality forces hotel building facilities and installations to be maintained to the highest standards, thus renovations are becoming common to remain competitive. This offers great opportunities for promoting renewable energy sources (RES) and rational use of energy (RUE) in the hotel sector. The Balearic Islands have been one of the first tourist destinations; there are about half a million beds available. There is a rise in the number of hotels that, while improving the energy facilities, can supply a part of the energy consumption by RES, without change the comfort.

Key words

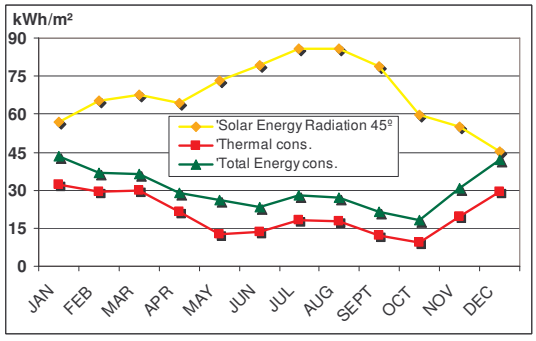
Energy Audits, Hotel, Renewable Energy, Solar Energy, Solar Assisted Air Conditioning.

1.Actual situation

The Mediterranean region presents favorable conditions for the application of Solar Energy, because when there is more radiation there are more visitors. Only Spain lodges every year more than 80 million visitors, and more than the 50% arrives in the summer period looking for the sun and the beach. A 10% of these visitors come to the Balearic Islands, and in summer there is a big increase of the energy consumption, especially due to the Hotel Sector and the rest of the tourism services.

The solar energy is only the 0,5 % of the total energy consumption in Spain and the 0,1% in Italy and France, very small if we compare with the 8,4% of Greece, if we consider that all these Mediterranean countries have a similar solar radiation. [1] Hotel sector is uniquely placed to provide the impetus for change in business behaviour in the tourist sector, 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.

Figure 1. Energy consumption in Balearic Island's Hotel vs Total Solar Radiation



Source [2].

Hotels rank in the highest levels of energy consumption in the tertiary building sector. Most of the existing hotels in the Mediterranean basin were built during the 1970 – 1980s. Low quality buildings, at least for today's standards, energy consuming installations, low performance equipment, as well as unsustainable exploitation of the natural resources, are common features of these constructions. Hotels are usually located in areas with high seasonal energy loads, and frequently with high energy cost and low supply (i.e. islands).
Energy consumption in hotels is among the highest in the non-residential building sector in absolute values (for example, per year is 215 kWh/m² in Italy, 287 kWh/m² in Spain, 280 kWh/m² in

Greece, 420 kWh/m² in France) [4]. Considering the fact that the building's operational costs will grow with time and that problems will get worse unless some actions are taken, there is a clear need for proper maintenance, refurbishment or retrofitting (upgrading) of the building. Such actions should focus on the structural building elements and installations that can also improve the energy performance and the indoor environmental quality.

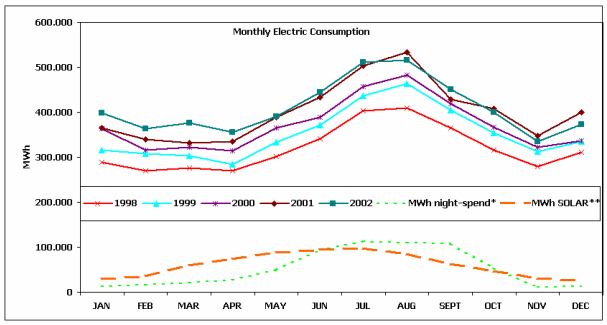
2. Objectives

The objectives are first to analyse the potential of renewable energy sources (RES) application in the hotel energy consumption and second to find out solar energy application in the Hotel energy process.

3. Case study

The Balearic Islands have more than 2.500 Hotel industries that imply an increase of 50% of the population at high season and an increase of the electric consumption of a 100%, almost 97% of Balearic's Electric energy comes from imported fuel and coal. The Balearic Islands are a typical example of centralized energy supply system based on the work of a large coal thermal power plant. Low reliability and high emissions are some of the problems inherent to this configuration. Highly oscillating demand curves and increasing energy consumption are added problems in this case.

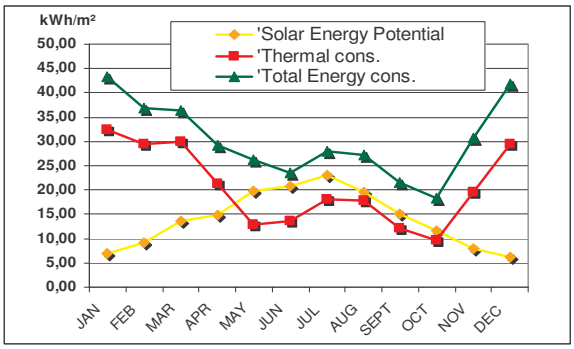
Figure 2. Monthly Electric cons. in the Balearic Is.(MWh)



Source[2]. Years 1998-2002

The Balearic Government, during the last years has performed energy audits at hotels to check out the energy management of the hotel owner and find out occasional tactics that can improve the energy efficiency and the opportunities to install RES.
The average annual energy consumption in the Balearic Hotels is 150 kWh/m² at the season hotels (open 6 months) and 250 kWh/m² at the rest of the hotels (open all the year). More than 50% of the total energy demand of hotels comes from thermal demand, HVAC and domestic hot water devices. This energy consumption increases during summer months when the solar radiation reaches its maximum values. This fact allows for large reduction on the fossil fuel used via solar energy facilities.
Total energy consumption for domestic hot water may represent between 12%-36% of total energy consumption and varies according to the hotel category and weather conditions. Average annual energy consumption may reach 1.300-5.000 kWh per bed.

Figure 3. Annual Energy use and Solar potential in 400 beds hotel at the Balearic's Is



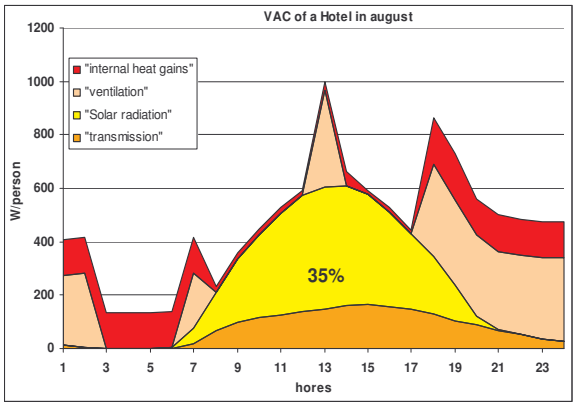
Source[2]. 2002

The average annual energy savings from solar collectors potentially can reach 550 kWh/m^2 [9] of collector area, they can be used to cover a significant part of the energy demand for sanitary and pool water heating (80%) all the year. In order to appreciate the importance of the renewable energy potential, it is shown that by multiplying the solar energy radiation per square meter per 1 or 2 m^2 for every bed available, depending of the solar collector efficiency (40-80%), we can almost balance the electric energy demand of the hotels in the high season. Although a 50% is a quite large efficiency for the solar-electric converters available nowadays, the figure is not so exaggerated if we take into account that a great part of the electric energy consumption goes for thermal uses.[1]

Hotels that have installed solar collectors at the roof of the hotel to cover more than the 60% of the domestic hot water demand, may have an excess of energy at summer (see figure 3) due to; low occupancy, reduction of hot water consumption or using of heat recovery systems from the chillers. This installation usually needs a system for dissipating excess of energy.

On the other hand, the buildings during the maximum solar radiation time have to neutralise this to maintain the internal comfort temperature with the use of more electricity for the standard chillers. This can be more than the 30% of the total daily heat gains. This increase is higher at rush hours when the electricity used by the standard chillers is more expensive for big companies like hotels.

Figure 4. Daily Heat gains of a Ventilation and Air Conditiong system in a hotel at the Balearic's Is.



Peaks in electricity demand occur more frequently during the summer period in the course of recent years at most developed countries due to the increasing use of air-conditioning [5].
This has increased the electricity consumption at summer and it has gone beyond the most pessimistic previsions of the Spanish government and electric companies and it has produced some blackouts in the last years in different areas.

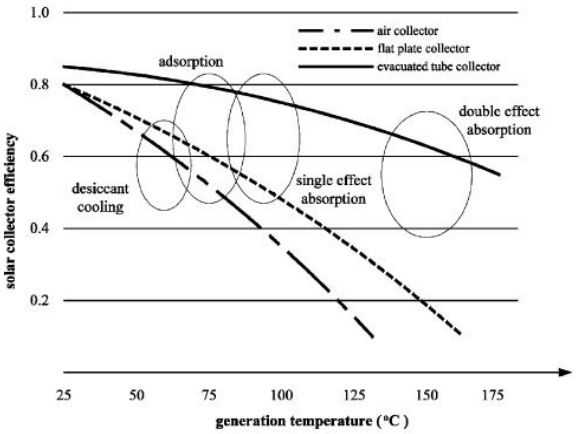
Table 1 Figures of room air conditioners in southern European countries

Country	Sales in Thous.	Total stock in use in thous.	Cons. (GWh)	Peak load Contr. (GW)	CO_2 emission (tonnes)
Greece	150,88	744,83	1.321	1,72	99.235
Italy	439,49	2.111,74	4.394	4,25	182.591
Spain	318,00	1.369,0	2.396	2,62	90.000
Portugal	45,80	322,82	613	0,46	147.538

Source[5]. 1996

Furthermore, many critical points have been identified in the power transportation grid that can cause the failures of the whole system [3]. Many of these problems are inherent to isolated centralized energy systems.
Using tri-generation systems is a solution that increases the energy efficiency and reduces a part of the electrical problems due to thermal uses. However none of these solutions will neither fulfill all the needs of the Balearic power system nor profit the high potential in RES of these islands. That way, new solutions are needed for assuring the energy supply.
In addition, at most tourist areas the hotels open only six months, from mid-April until mid-October, while there is less number of open hotels all year round [6]. Moreover, these are complicated systems that need qualified personal and work more that 4.000 hours per year. This makes that co-generation or tri-generation systems are only economically attractive for hotels of more than 600 beds or open more than six months. In buildings of the tertiary sector with natural gas pipe and with a big and constant consumption during the year is interesting the use of Tri-generation system with an efficiency of the 85%, and a 50% of reduction of the primary energy consumption, a 24% of the CO_2 emissions with pay back under the 5 years [2].
For the rest of the hotels and buildings is more interesting For the rest of the hotels and buildings solar thermal energy is more interesting, both for hot water production and to assist the HVAC systems. The use of solar energy with desiccant systems (DEC-system)[9] or small sorption chillers allows the thermal energy to be used for cooling and heating. These systems can be combined with the recovery of heat rejected by the cooling facilities (i.e. recover waste heat from cooling towers as useful energy) can also be used to reduce energy consumption for service hot water and swimming pool water heating. Additional benefits, in this case, originate by improved efficiency of the cooling towers and reduced operating hours that provide additional savings [7].

Figure 5. Possible combinations of solar thermal and sorption refrigeration technologies

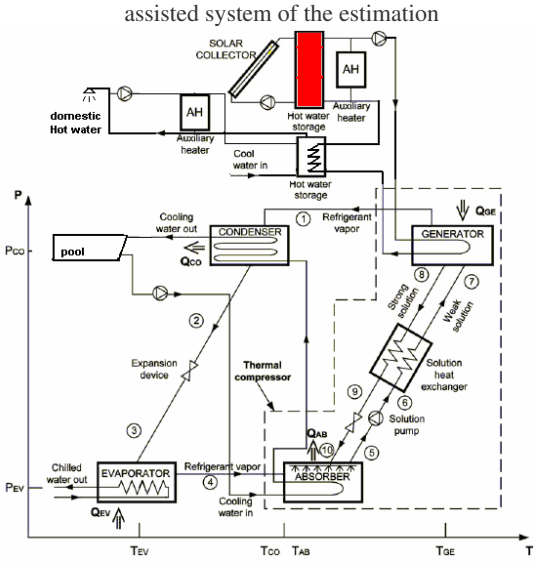


Source[10]

From the information of the energy audits of the Balearic Islands hotels ha been used to forecast three different future scenarios: the first one using 1m^2 of selective flat plate solar collector per bed for hot water production, the second using 1.5 m^2 per bed available for hot water and solar assisted heating, the third one using 1.5 m^2 of selective flat plate solar collector per bed for hot water production and for solar assisted heating and cooling with absorption chillers of Li-Br with a power of 200W per bed available.
The results of the estimations are the following; in the first scenario with an investment under 300 € per bed and a pay-back ratio under 7 years, we get economical savings of primary energy more than the 15% and covering the 83% of the hot water energy consumption. The second scenario with

400€ per bed and a pay-back under 9 years, we get economical savings of primary energy more than the 18% and covering the 98% of the hot water energy consumption. In the third scenario, with an invest of 460€ per bed and a pay-back under 8 years, we get economical savings of electricity and primary energy more than the 24%, even for hotels with low occupancy. The difference lies that on the third system never is going to be solar energy in excess.

Figure 7. Diagram of the solar hot water and cooling assisted system of the estimation



Source [5]

In Greece, where the solar energy is more used, the annual energy savings can reach 350 MWh from the solar collectors, 40 MWh from the heat recovery in the cooling equipment, 12 MWh from using excess heat of the cooling system to heat the pool water, and additional savings of 43 MWh as a result of the reduced cooling tower operation time.[8]

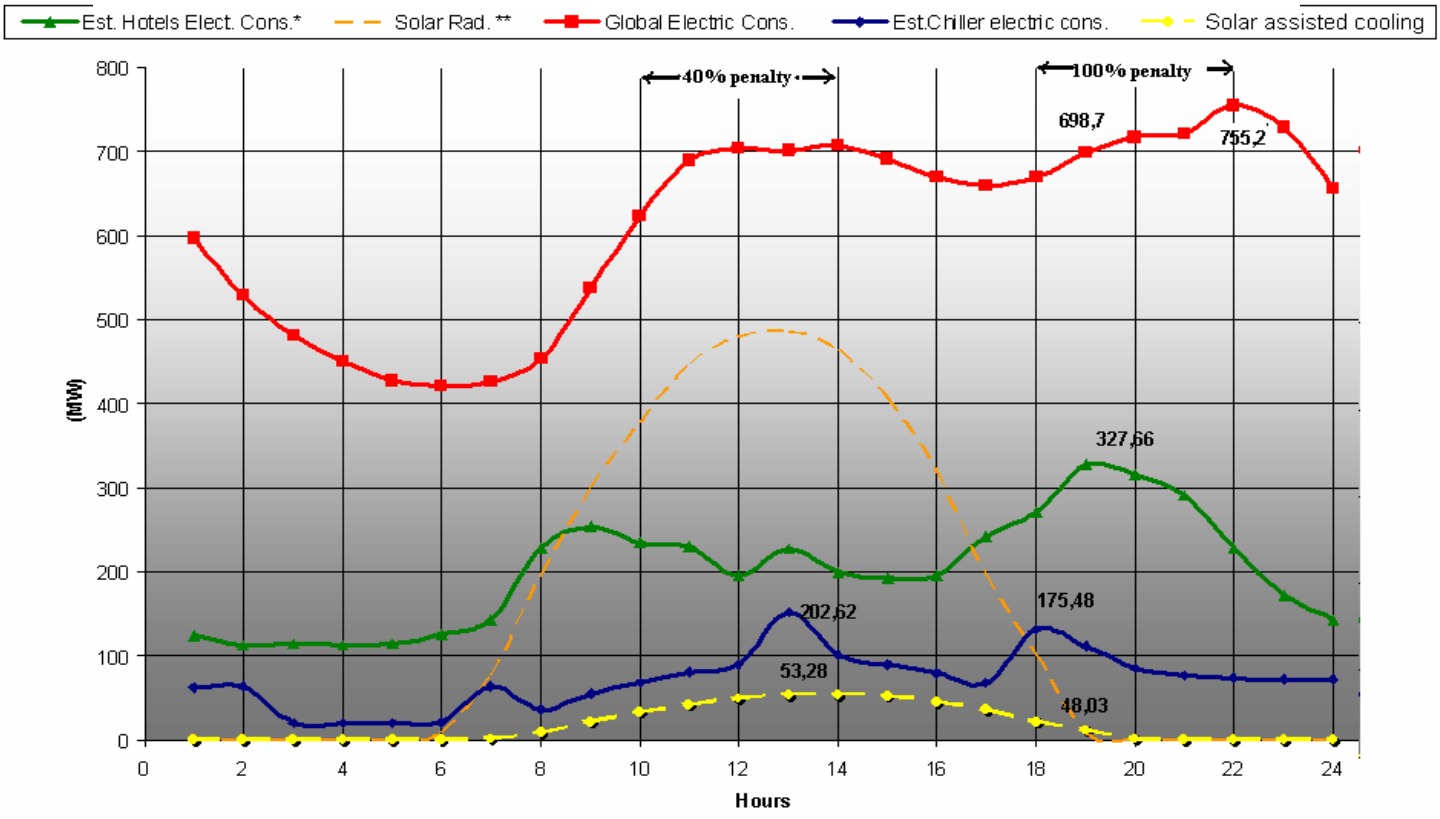
Table 2 . Identification of savings measures in 400 beds hotel at the Balearic's Is.

Action	Invest.	Annual savings			pay-back
	€	MWh	Kg CO_2	€	year
Regulation*	3.710	139,0	485	8.573	0,43
Heat recovering/ water condens*	6.750	106,0	369,7	6.551	1,03
Technology changes*	18.000	21,5	75	8.937	2,01
Solar Thermal for Water heating (83%)	121.000	361	1.262,1	18.027	6,71
Co-generation High thermal demand	128.000	649,4	2.272	18.580	6,89
Solar Thermal for Water heating (98%) & HV	184.500	419	1.467,9	21.137	8,73
Solar Thermal for Water heating (98%) & HVAC	205.500	435	1.522,3	27.937	7,36
Tri-generation*	250.000	1100	3.848	26.131	9,57

***Source[1]. 2004**

The efficiency of the hotels is lower than the 60% including the electricity transformation, the power station at the Balearic Islands have a lower efficiency (36 %) than the tri-generation systems (82%)[3], they will be one of the options to reduce the impact of the growing energy consumption.
The solar thermal applications are the best action at the southern Europe countries. The photovoltaic systems only with fiscal incentives are interesting from an economical point of view, and the new generation of hybrid systems with lower costs could be a perfect system to solve the thermal and electric necessities in Tertiary Buildings without fiscal incentives.

Figure 8. Average of a Balearic's electric daily Prod-Cons.(MW) with cooling cons. and solar assisted cooling at hotels.



On the other hand, the close coincidence of the maximum solar radiation with both the cooling loads and the peak electricity demand indicates that solar assisted refrigeration may be an interesting option to handle successfully the issue of reducing peak electricity demand due to air-conditioning. At the figure 8 is shown that at Balearic Islands the solar assisted cooling may suppose a reduction of 25 MW of peak if was installed in the 50% of the hotels.

The same system that have been proposed in this paper can be studied with commercial evacuated tube or concentration solar with orientation system. If the cost of these systems were as the flat plate, the pay-back would be reduced by the increase of the efficiency of solar radiation collection at higher temperatures. In a few years the pay-back of these systems would be less than five years.

4. Conclusions

A high amount of the energy consumed by the tourist sector it is used in thermal applications, especially in HVAC. The use of renewable energies or tri generation plants can improve a 40 % the efficiency of the system.

Using solar energy for water heating and HVAC is a good solution in order to have the maximum profit of the solar collectors all year round and reduce the pay-back time.
The direct consequence is that for the same energy consumption, the tri-generation plants or the solar thermal energy would consume between a 20 to 40% less of fuel with a consequent reduction of CO_2 emissions with pay-back times of less than a decade.

The integration of RES in the energy production at smaller or temporally occupied hotels, especially solar heating and cooling technologies, seems an excellent chance for hotel managers, especially for summer hotels. As far as the economics and legislation are concerned and beyond conventional measures like fiscal incentives, one could mention the following actions that could promote a more environmentally conscious evaluation of solar systems: the quantification and internalisation of the environmental benefits of solar designs/technologies, the trade-off analysis of environmental issues and solar building strategies, the economic analysis and quantification of CO_2 reductions from solar buildings, and the adaptation of a common life-cycle analysis method to evaluate the alternatives.

Acknowledgement

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