Net zero energy in hotels and touristic areas in the Balearic Islands EuroSun 2010

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Abstract

Tourism is the most developed economic sector in the Balearic Islands. The great rise in construction activities within the last 50 years, the increase in energy consumption, in CO_2 emissions and in waste production due to tourism, as well as an electrical energy production system mainly based on coal and fossil fuels is not an environmentally sustainable scenario [1]. The aim of this study is to identify the processes that reduce energy consumption and greenhouse gas emissions, designing a target scenario featuring "zero CO_2 emissions" and "100% renewable energies" in tourist buildings and tourist areas. The energy costs, CO_2 emissions and waste materials generated by a sample of hotels and tourist areas from the Balearic Islands studied will be used in this study. The results show possible processes and infrastructure changes than can reduce the CO_2 emissions between a 50 and 100% and find out future net zero energy building scenario.

1. Introduction

Hotels rank on the highest levels of energy consumption in the tertiary building sector. Most of the existing hotels in the Balearic Islands were built during the 1970 – 1980s [1]. Low quality buildings, considering modern standards, large 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.

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) [3].

The Balearic Islands have more than 2.500 Hotels with 422.918 beds, where almost the 10% it's located at Palma Beach. These buildings have an average energy consumption of 150 kWh/m² per year. This energy consumption increases during summer months, when the solar radiation reaches its maximum values. In addition, for most tourist areas, hotels only open for a six month period, from mid-April until mid-October, while only a few hotels open all year round. Moreover, these year-round hotels are complicated systems that need qualified personal and work more that 4.000 hours per year. With this actual condition makes that co-generation or tri-generation systems only economically attractive for hotels of more than 600 beds or open more than six months. In buildings of the tertiary sector, with access to natural gas and a large and constant consumption throughout the year, the use of

Tri-generation system would be of great interest, with an efficiency of 85%, a 50% of reduction of the primary energy consumption, a 24% of CO2 emissions, all with a pay back of less than 5 years [2].

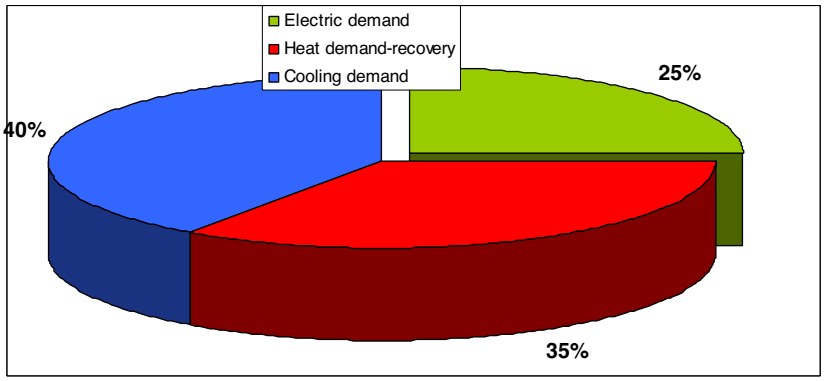

Fig. 1. Estimation of annual energy consumption of tourist and residential area in Palma Beach.

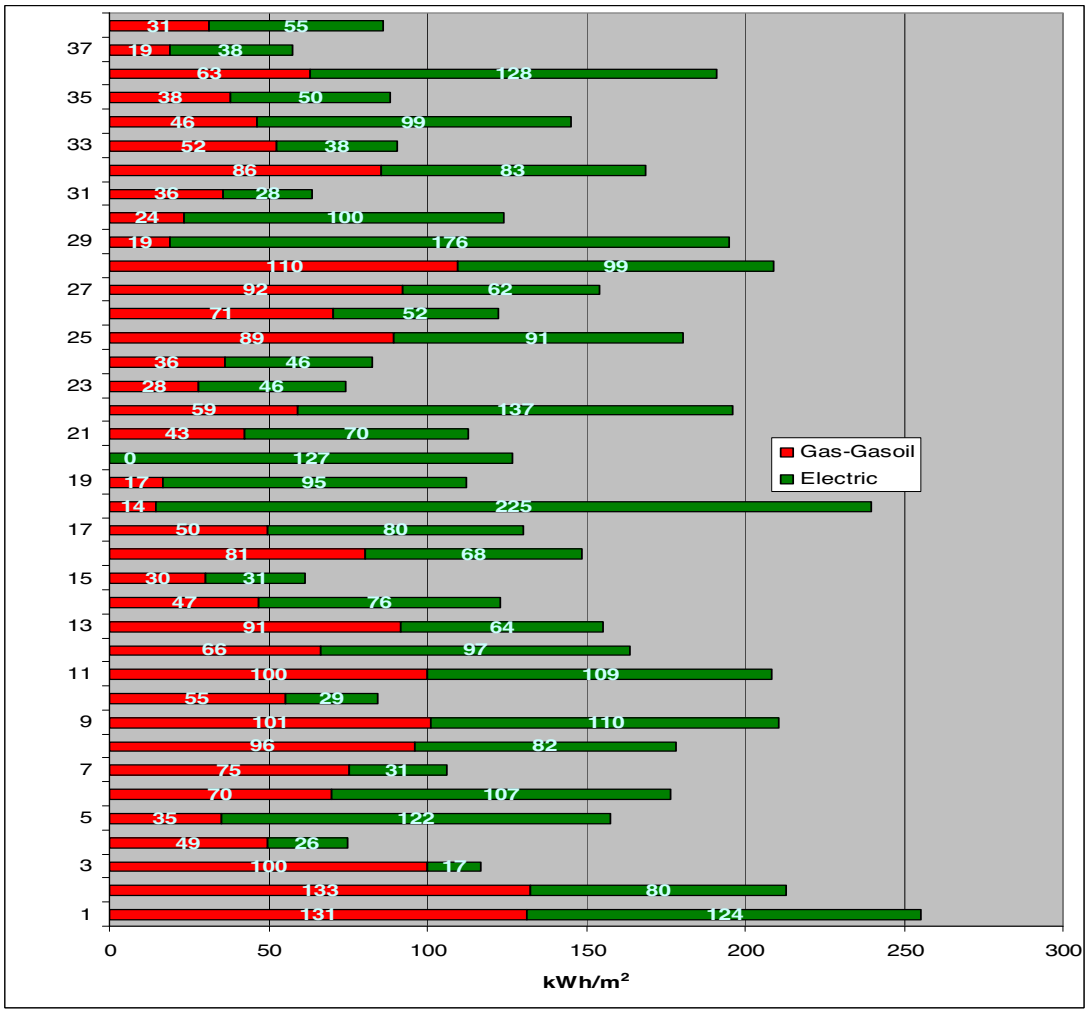

Fig 2. Total annual consumption of a sample of hotels in the Balearic Islands.

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 thermal envelope of the buildings and on installations that can also improve the energy performance and the indoor environmental quality.

The biggest problem of the Balearic Island's hotels is that about the 50% of the energy consumption is electric (Ventilation-Air Conditioning, lighting and others uses) and the other 50% is from gas or fuel (Heating, Kitchen, Hot Water and others..) [2].

In the case of the electric consumption, the CO_2 emission factor for the production of electricity in the Balearic islands is 0,86 kg CO2/kWh while in Spain it is only 0,4 kgCO2/kWh[1]. This is due to the fact that the electric production in the Balearic Islands is mainly based on non-renewable energy sources, coal is the most used primary energy and renewable energies amount only to less than 1%, while in the continental Sapin reached a 21% during 2007 [1]. This point should be taken into account if we want to achieve a net zero energy scenario.

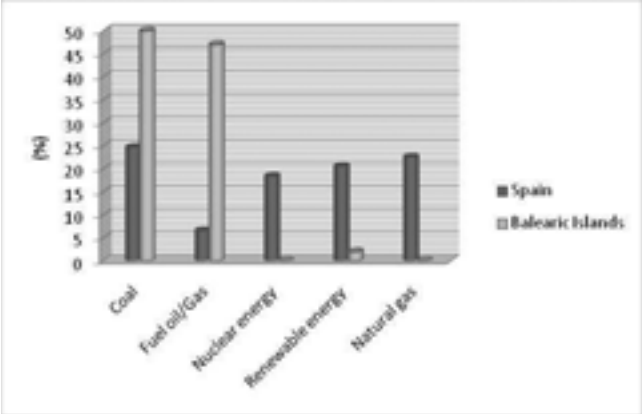

Fig. 3. Electrical energy production mix. 2007. [1]

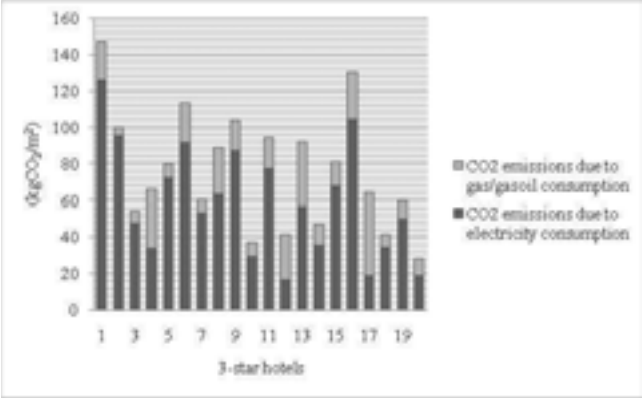

Fig.. 4. CO_2 emissions in the operation phase from a sample of 3-star hotels in the Balearic Islands.

2. Net zero energy

The integration of RES in the energy production in smaller or temporally occupied hotels, especially solar heating and cooling technologies, seems an excellent chance for hotel managers, especially for summer hotels, combined with biomass. The biggest problem of the Solar Energy technology and Biomass is a big initial investment that is only used during the summer months, when the hotel occupation is high, like the trigeneration systems. This could be solved using smart grids, with a bidirectional district heating and cooling system, where the buildings can buy or sell energy according to their necessities. Integrating photovoltaic and urban wind turbines in the electrical grid, and creating Central Heating Power Plants with biomass and solar thermal collectors can be the ideal scenario. There is a new fact to be studied; most of the tourist areas had a vacation home area that nowadays has become, with the increase of the house prices, a permanent residential area. These residential areas have more constant energy demand throughout the year than the hotels; this reality can develop a new scenario with a good symbiosis with the hotels energy systems. The Palma Beach has in summer the same number of tourists than people living in the residential areas. This makes even more interesting to create smart grids for the sharing thermal energy resources between buildings.

Actually there is a big project, a Town Planning Consortium, for the improvement and landscaping of Palma Beach, which is set up with the aim of promoting the refurbishment of hotels, complementary tourism services and the area in general [5], with an investment of 4.000 M€. One of the main objectives is to reduce CO_2 emissions. This is would be an opportunity for promoting solar systems combined with District Heating and Cooling with the quantification and internalization of the environmental benefits of solar 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 definition of a standard life-cycle analysis method to evaluate the alternatives.

For the larger hotels with a high occupation, a very attractive option will be tri-generation plants using biomass combined with solar energy, which could sell the thermal and/or electrical excess to the District heating and cooling net and to the electrical grid. This smart grid will help to the smaller buildings and residential areas to reduce their operating costs and emissions, taking profit of the shared resources.

Due to the use of AC systems, for many hours a day, the tourist and commercial buildings (hotels, shops, restaurants,) should dissipate to the ambient a large amount of thermal energy that could be used in the residential areas or service buildings to produce domestic hot water, which is one of the most common uses. Only sharing the energy in this bidirectional system ("Energy net" [4]) a big reduction of the CO2 emissions of the buildings (5-10%) could be achieved, (or a 50% of the emissions related to thermal uses).

With rising petrol prices, biomass and solar energy for electric and thermal applications, like combustion for heating-cooling or electricity production is gaining interest.

In Spain this year ends the Renewable Energy Plan 2005-2010(REP), one of the objectives of this plan was to arrive at the end of this year to a 12,1 % of biomass for primary energy production, but it is impossible to archive this objective, because at the beginning of this year was the 3,3%.

The Balearic biomass market for energy purposes is still small, with an estimation of Biomass production of 2.101.098 tons per year, with a potential of 365 ktoe, and an estimated current consumption of 49 ktoe, which means only the 11% of the biomass is used, and only for thermal application in local industries and some hotels.

However, the market may face imminent change, as several new market players are interested in producing pellets, distributing pellet stoves or adapting their equipment to pellets.

Domestic hot water may represent between 12%-36% of total energy consumption in hotel building, and varies according to the hotel category and weather conditions. Average annual energy consumption may reach 1300-5000 kWh per bed. The average annual energy savings potential from solar collectors can reach 550 kWh/m^2 [2] of collector area, and they can cover a significant part of the energy demand for DHW and swimming pool water heating, which, if combined with absorption chillers, can also be used for cooling. The use of heat recovery from the cooling system (i.e. recovered waste heat from cooling towers as useful energy) can also be used to reduce thermal energy consumption. Additional benefits, in this case, originate from improved efficiency of the cooling towers and reduced operating hours which provide additional savings [2]. In Greece 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. [2]

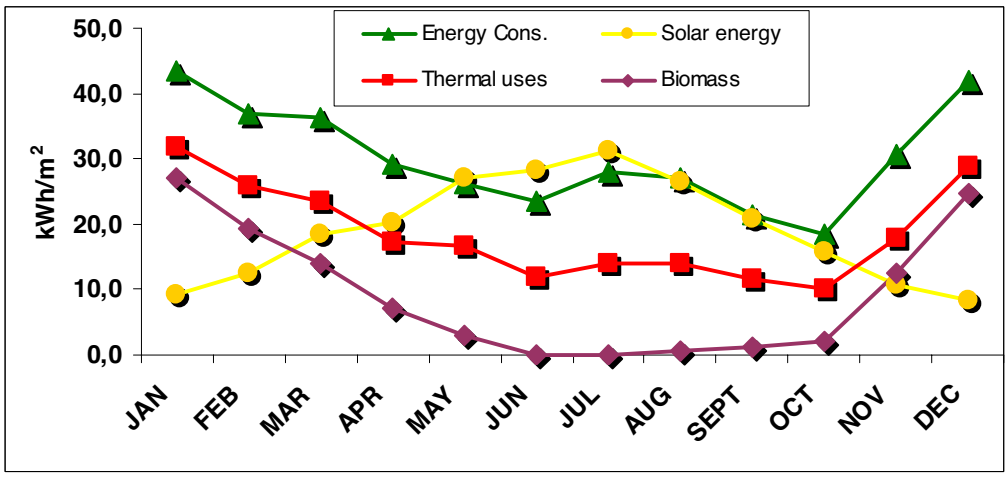

Fig. 5. Annual Energy use and Biomass and Solar potential in a hotel at the Balearic's Is

In order to appreciate the importance of the renewable energy potential, it can be shown that by multiplying the solar energy radiation per square meter per 1 or 2 m2 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. [2]

Hotels that have installed solar collectors atop of the roof of the hotel covering more than the 60% of the domestic hot water demand, may have an excess of energy in summer due to; high solar radiation, 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, buildings during the maximum solar radiation time must neutralize this heat gain to maintain the internal comfort temperature, this can imply more than the 30% of the total daily heat gains. This increase is even higher at peak hours, when the electricity used by the standard chillers is more expensive for large businesses like hotels.

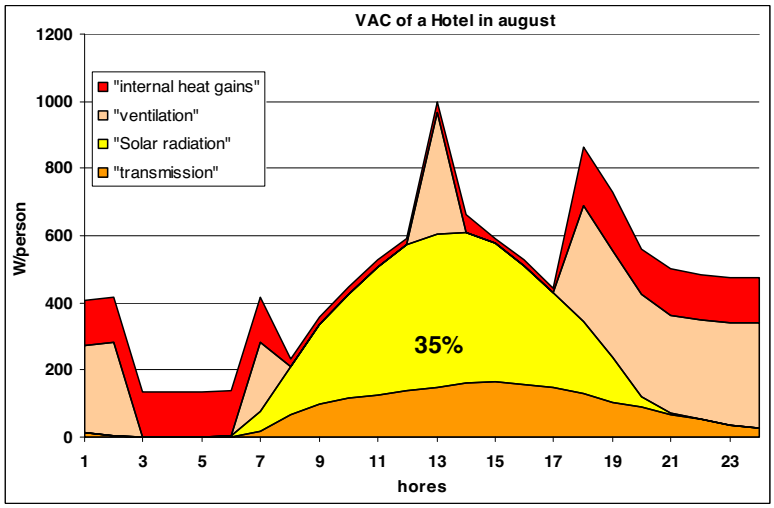

Fig. 6. Daily Heat gains of a Ventilation and Air Conditioning system in a hotel at the Balearic's Is.

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) or small sorption chillers allows the thermal energy to be used for cooling and heating. The big investment of solar panel can be reduce combining with biomass, that have less investment and combines perfectly with de sorption technologies and thermal applications.

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 internalization of the environmental benefits of solar-biomass designs/technologies, the trade-off analysis of environmental issues and solar building strategies, the economic analysis and quantification of CO2 reductions from solar buildings, and the adaptation of a common life-cycle analysis method to evaluate the alternatives. The integration of RES in the energy production in hotels, especially solar heating and cooling technologies, seems an excellent challenge for hotel managers, especially for summer hotels.

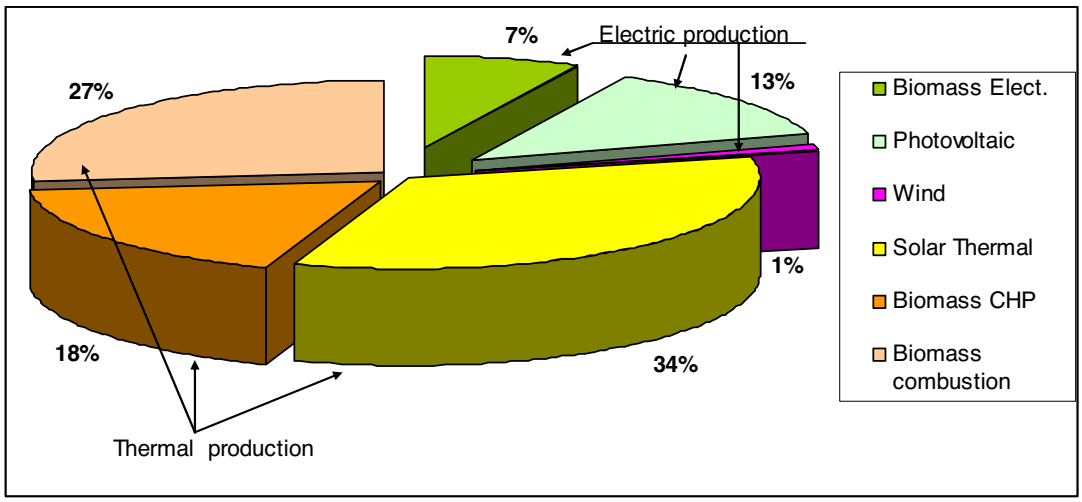

Fig. 7. 100% renewable energy scenario in Palma Beach Area.

With a mix combining cogeneration with biomass, photovoltaic, wind, solar thermal and biomass for combustion it can be a 100% Energy scenario in Palma Beach. The total invest estimated will be around 100 M€, that is the 3% of total investment cost of the project, with a pay-back of 10 years. The advantage of this system will be the incomes for local companies of biomass against the import of fossil fuels, and the will create a lot of new jobs in the area for maintenance and operating companies.

The cost in thermal applications is actually smaller than with fossil fuel. The electricity generation with a renewable mix will be a 5% higher that the actual cost. The fully-loaded cost of the photovoltaic electricity is about 0.20€/kWh in most of the OECD countries. There are estimation that said by late 2011, the fully-loaded cost is likely to fall below 0.15€/kWh for most of the OECD and reach 0.10€/kWh in sunnier regions like Spain with pay-back times of 20 years. The Grid parity it's a reality in Canarias Islands and we will probably reach it in some years in Balearic Islands.

3. Conclusion

Using solar energy for water heating and HVAC is a good solution to gain the maximum profit of the solar collectors whole year round and reduce the pay-back time less than a decade.

High quantities of biomass residues (agricultural, forestry and industrial ones) are produced in the Balearic Islands and could be used for energy production, for example, for combustion and cogeneration plants.

Using biomass for combustion only for HAVC and hot water can reduce the CO_2 more than a 50%, combining this technology with solar assisted system it reduces the pay-back of the whole installation, and reduce the Balearic Island's external dependence of source of energy and to arrive to a net zero energy.

The tri-generation plants, in hotels or in District Heating and Cooling grids (DHC), can improve a 40 % the efficiency of the system having a lower investment cost. Using solar energy combined with

biomass, and selling the excess heat to the DHC grids is a good solution in order to have the maximum profit of the solar collectors all year round and to reduce the pay-back time.

The integration of Biomass and Solar Energy in the bidirectional DHC grids in tourist areas combined with tri-generation plants with biomass supply and photovoltaic, wind turbines and solar thermal energy would consume a 40% less energy and make a reduction of 100% CO_2 emissions.

Actually the net zero energy building scenarios in tourist areas is economically and technically possible only with a credit help for the initial investment, with pay-back times of less than a decade.

References

[1] B. Rosselló-Batle, A. Moià, T. Cladera, V. Martínez. Energy Costs, CO_2 Emissions and Waste throughout the life cycle of a sample of hotels in the Balearic Islands. Energy and Buildings 2010.

[2] Energy Policy and an Action Plan for Renewable Energy Sources (RES) in Mediterranean islands Hotels: Policy and Energy audits in the Balearic Islands Hotels A. Moiá-Pol, Michalis Karagiorgas, V. Martínez-Moll, Carles Riba-Romeva. Procc. International Conference of Renewable Energy and Power Quality ICREPQ. Universitat de les Illes Balears.(2006).

[3]Argiriou AA, Balaras CA, Dascalaki E, Gaglia A, Gountelas G, Moustris K, Santamouris M, Vallindras M. Energy audits in public and commercial buildings in Greece, Proc. 3rd European symposium: soft energy action at the local level, Chios (Hellas), 11–14 September 1991.

[4] Jeroni Cabot Jaume. “Energynet”. Diario el Mundo. Especial Tecnoturística, pag. 140. Madrid 2000.

[5] Consorci Urbanístic Platja de Palma 2009. http://consorcioplayadepalma.es/