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Thermal applications of biomass in hospitals

Justo García Sanz-Calcedo[1], Angel Mena[2], Francisco Cuadros[3], Fernando López[3]

Abstract — The aim of this study was to evaluate the feasibility of using renewable energy from biomass for the production of heat and cold in hospitals, examining the feasibility of establishing such facilities in Extremadura (Spain). In its development, has been taken into account the technical aspects related to the operation of this type of heating, including reliability and maintainability of them, assessing the problems generated by the introduction of renewable energy from biomass in publics buildings.

It has been shown that high consumption of hot water and heating systems consume annually make the hospital a great place for the installation of thermal production systems based on biomass, because the necessary demand and its continued operation, promotes amortization. In addition, it was found that promoting the use of renewable energy through biomass, can help create and consolidate a native biomass market, emerging at the beginning of this project and in the consolidation phase at the present time, that eventually will get an economic improvement in rural areas, promoting its development.

Keywords — Hospital biomass, energy efficiency, environmental performance

1. Introduction

The installation of systems based on thermal power generation with biomass in the tertiary sector buildings, is one of the current challenges facing the renewable energy sector, which is still under development in Spain for the biomass [1], although existing technology through biomass energy conversion ensures the efficient operation of these facilities [2].

In Europe, the contribution of biomass in 2008 was 68.7 Mtoe [3], which represents an approximate average of 0.138 toe per capita. In Spain, the consumption of biomass in the same year was 4.34 Mtoe, which means that each Spanish consumed an average of 0.096 toe, that is, in Spain the average consumption of biomass per year, is 30% lower than that corresponds to the European average.

A measure that contributes to the implementation of biomass facility is to serve as demonstration of the benefits of this technology, mainly in public buildings, which are frequently visited by large numbers of users. This is the case of hospitals, buildings that operate continuously and are highly frequented.

In Spain, the thermal energy consumption in hospitals, both in heating and hot water is around 40% of total primary energy consumption of each building [4].

The main objective in the production of thermal energy in a hospital, is to ensure maximum comfort conditions for patients and workers, taking into account the cost, the fuel supply conditions and environmental impact. In addition, measures to improve energy efficiency of a hospital should take into account climatic and local conditions [5] as well as indoor climate environment [6] and cost-effectiveness and should not contravene other essential requirements this type of buildings such as accessibility, security of electric supply [7] and reliability of its facilities.

The use of biomass as a fuel can achieve these objectives, promoting the use of renewable energy that are available in abundance in Extremadura [8], using indigenous sources and converting a waste into resource, thanks to its energy use [9]. However, the background to the use of biomass [10] has few precedents in hospitals [11-12].

1. *Justo García Sanz-Calcedo is with the Department of Mechanicals, Energetic and Materials. University of Extremadura. Avda Sta. Teresa de Journet s/n (06800) Mérida. Spain. E-mail: jgsanz@unex.es*
2. *Angel Mena Nieto is with the Department of Design and Project Engineering. University of Huelva. Ctra. Palos de la Frontera s/n (21071). La Rábida, Palos de la Frontera (Huelva) Spain E-mail mena@uhu.es*
3. *Francisco Cuadros Blázquez is with the Department of Applied Physical, University of Extremadura. Avda. Portugal s/n. (06010) Badajoz. Spain. E-mail: cuadros1@unex.es*
4. *Fernando López Rodríguez is with the Department of Graphic Expression. University of Extremadura. Avda. Portugal s/n. (06010) Badajoz. Spain. E-mail: ferlopez@unex.es*

2. METHODOLOGY

To obtain operational data were analyzed two facilities: One-burning power crushed olive stones, used to cover part of the thermal demand of the Hospital de Zafra (Badajoz), and two biomass boilers using shell Almond for heat production in winter and cool in summer, feeding a simple absorption machine effect on an administration building of the Extremadura Health Service.

During the course of the study, conducted energy audits [13] that allowed to know the real situation regarding energy management and facilities, and were used as the technical basis of the analysis.

To analyze the reliability and maintainability of the facility, introduced each of the components of the system in the maintenance plan of the building, assigning a specific time to each of the tasks of maintaining each installation. Was timed daily time spent on maintenance of the biomass boiler and its ancillary facilities, as well as dedicated to locating and troubleshooting. In addition, data were monitored the overall performance of the installation.

The data collection process was completed with those obtained in the historical archives of Engineering and Maintenance Service. A brief description of each he facilities monitored in the study.

2.1. Installation of the Zafra's Hospital

The biomass boiler was installed for heating and hot water, works together with existing ones. This is the model-430 Manufacturer Bioselect Lasi, has an output of 430 kW, is made of sheet steel with three-step vertical flue cleaning system, and operates at a pressure of 4 bar. The biomass burner is modulating cascade type with automatic ignition and ash pusher system, incorporating a retrieval system of solid particles by using the cyclone effect. In Fig. 1 it shows a view of this power plant.

Figure 2. Thermal power plant installed in the building of Mérida (Badajoz)

To achieve greater efficiency by regulating the heat demand, has provided a buffer tank of 2,000 liters, which acts as a heat sink that prevents multiple burner starts, optimizing its performance and extending the life of the facility [14]. The working temperature was regulated at 84°C.

Figure 1. Thermal power plant installed in the Hospital of Zafra (Spain)

2.2 Installation of the health service building

Heat production is done using two identical shell boilers, the Spanish manufacturer Vulcano, with thermal power 465 kW each, which they use as biomass fuel, currently almond shells, from the food industry. It has a storage silo that is located separately from the boiler room with a capacity of 70 m³. In Fig. 2 shows a view of the boiler room of the building.

Cold production is done by a water chiller Carrier brand, with 545 kW nominal cooling capacity of simple effect absorption cycle with lithium bromide as absorbent and water as coolant, fed by hot water from boilers described above, condensing through a cooling tower with cooling capacity of 1,203 kW.

Designed work system is inertial, ie there is no immediate response to thermal stresses of the building, and by the absorption machine, or by biomass boilers, as there is no immediate response stops installation. Thus we have installed a storage system, replacing in part to the lack of instant response of the boilers, and facilitates the activation temperature of the generator.

The facility has a system of hot water storage at 92°C, consisting of three tanks of 10,000 liters each. This accumulation allows sufficient thermal power will be supplied to the generator at the same time helping to make the boiler temperature regime. This accumulation allows a momentum of 400 kW in heating mode for the building during the winter season.

The facility has four cold water storage tanks of 5,000 liters each that hold water at 7°C is used for starting early, corresponding to 15% of the partiality of the absorption chiller.

3. RESULTS

For to determine the thermal energy of a hospital, we have analyzed the average consumption of natural gas and diesel from various hospitals in Extremadura Health Service, detecting that is proportional to the number of beds in the same.

If both parameters are plotted using a scatter diagram, there is a relationship between two variables, so that using tools data processing, can be calculated by the regression line linking the two and that can be seen in Fig. 3, with a R^2 of 0.9436 and in accordance with expression (1).

$$y = 16.46\,x + 1{,}635 \qquad (1)$$

Where y is the average annual consumption in normal operation and occupation, expressed in MWh and x is the number of beds in hospital.

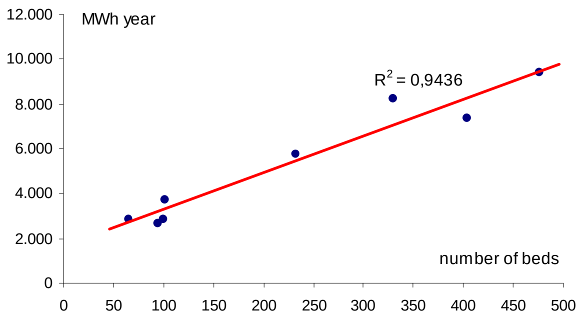

Figure 3. Relation between the annual consumption of thermal energy and the number of beds in a hospital

The results in the development of this study are presented below, classified according to the different effects observed.

3.1. Biomass fuel

In Extremadura, the types of biomass that can be used are dependent on market availability, the most common olives stone, pruning of olive and fruit trees to make wood chips, wood cuts from industries, shell nuts, forest residues [15], concentrates on the vine [16] and pellets.

We proceeded to assess the economic cost per kilowatt hour on the use of different fuels, given the transportation costs to the point of supply, compared with the costs of non-renewable fuels (diesel and natural gas), taking into account prices market (December 2010) for a consumption equivalent to that provided annually in a 100-bed hospital [17].

Biofuels have been tested to verify the feasibility of its use in hospitals, have been crushed olive pits, almond shells and different types of pellets.

In Fig. 4 are represented the final costs of different fuels expressed in cents per kWh unit of heat energy produced [18]. One can see that the olive pit is 20% cheaper than the pellet, 41% natural gas and 50% the fuel oil, all assuming that the performance of solid fuel boilers of less than by 6% to other boilers [19].

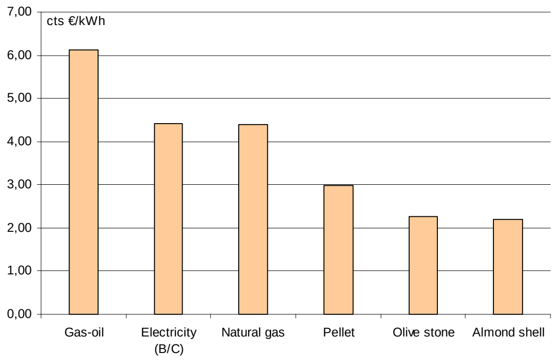

Figure 4. Cost per kWh of thermal energy produced by different fuels

In the medium to long term, the trend of increasing production costs of oil and its derivatives, clearly on the rise, increase the gap to biofuels, the cost tends to stabilize as a consolidation of industries engaged in rendering.

The crushed olive pits, is a type of fuel that comes straight from the milling process the olives in the mills, and is a by-product of olive oil production. The almond shell is a byproduct of the food industry, from the shelling of the almonds. Table 1 specifies the physical and chemical characteristics of both fuels.

Table 1. Analysis of the physico-chemical bio-fuels

Parameters	Olive stone	Almond shell
Size (mm)	< 5	< 11
Density (kg/m^3)	680	400
Humidity (%)	7.10	8.00
PCI (kWh/kg)	4.87	4.75
Ash (%)	0.55	0.97
Volatile (%)	74.25	75.04
Sulphur (%)	0.04	0.02
Chlorine (%)	0.064	0.02
Fixed carbon (%)	19.49	18.40

3.2 Maintenance

During the investigation it was found that the preventive maintenance of the installation of biomass has increased by 120% compared to similar facilities thermal energy production by diesel and /

or natural gas in hospitals due to cleaning, regulation and emptying the ashtray, which involves an additional task average 60 minutes per day.

On the other hand, has proven that the technology applied to biomass boilers, is less reliable than those used in natural gas boilers and diesel, particularly in the initial period of operation thereof. That is why the availability [20] of the facility is lower, so you should duplicate the facilities and / or have other support units with fuel.

In Fig. 5 shows the cost due to maintenance operations depending on the type of fuel used for heat production.

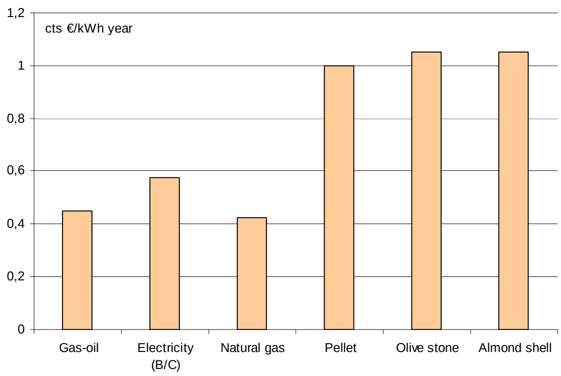

Figure 5. Annual cost per kWh of maintenance

3.3 Investment

We calculated the investment required per unit of useful energy for a conventional plant and other biomass, sensing that the installed capacity in the hospital, the initial investment required is 0.0955 €/kWh when using a facility diesel or natural gas, while for the installation of biomass, after incorporating subsidies, we need to invest € 0.1705 per kWh of useful energy.

In Fig. 6 it shows as reduce the costs necessary to implement the installation, the higher the power of the facility.

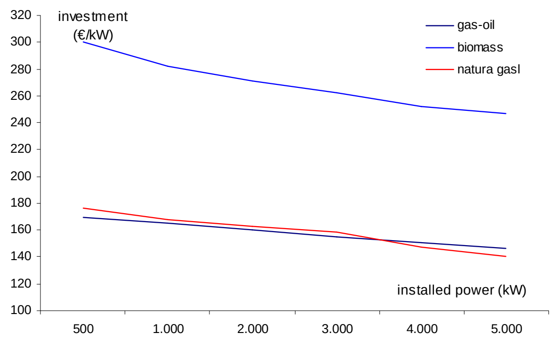

Figure 6. Relation between the cost per kW installed power and type of fuel

3.4 Environmental balance

The emissions of carbon dioxide in the combustion of biomass are nearly neutral, as the plant is able to retain plant during its growth more CO_2 than is released in combustion [21]. As for the other pollutants, emissions are so low that they are considered negligible, so that practically emitted by diesel or natural gas, agree with it avoided being replaced by biomass.

Table 2. Annual balance environmental

Emitions	Zafra	SSCC
NO_2 (kg)	- 5,852.81	-7,316.01
SO_2 (kg)	- 303.53	-379.42
CO (kg)	- 1,249.17	-1,561.46
CO_2 (kg)	- 242,829	-303,537
Particles (kg)	+ 140.72	+175.90
Ash (kg)	+3,276.27	+4,095.33

As can be seen in Table 2, the heat production by biomass alone increases the emission of particles into the atmosphere, consisting mainly of fly ash carbon, although the term particle includes those constituents, except pure water, present in the atmosphere in solid or liquid, larger than that of simple molecules and less than 100 microns. Still, it was found that the emission rate of particles is below the allowable limits for installation of solid fuel [22].

3.5 Amortization

To analyze the economic viability of the project, it has made a comparative analysis between the installation of diesel that was running in the hospital and the new biomass by calculating the annual cost of each fuel needed to produce the same thermal energy in the hospital.
Regarding the building SSCC has been compared to another based on production of cold and heat by heat pump air-air.

Table 3. Economic balance of the biomass boiler

Indicator	Zafra	SSCC
Investment	177,000 €	352,000 €
Grant	51,600 €	0
Installation cost	125,400 €	352,000 €
Annual saving	23,131 €	63,270 €
Pay-back	5,4 years	5,56 years
Saving (10 years)	231,310 €	632,700 €

As can be seen in Table 3, the total estimated savings over the life expectancy of the equipment [23], is € 231,310, giving a payback period of 5.4 years less than that produced in other types of production facilities based energy solar gain. In the administrative building, you get a return period of 5.56 years.

4. CONCLUSIONS

It has been shown that high consumption of hot water and heating systems consume annually make the hospital a great place for the installation of thermal production systems based on biomass, because the necessary thermal demand, as well as continuous operation favors the repayment of these facilities.

The permanent presence of maintenance staff in the boiler rooms of hospitals, allowing more time to absorb the operations derived from additional maintenance to this type of installation, due to the processes of household cleaning and ash removal. That is why for the implementation and development of renewable energies such, it is essential involvement of maintenance staff and operator training.

It was noted that promoting the use of renewable energy through biomass in hospitals, can help create and consolidate a native biomass market, emerging at the beginning of this project and in the consolidation phase at the present time, that eventually will get a rural economic growth, promoting development and reducing dependence on foreign fuel supply.

On the other hand, it has shown that need more storage space for such facilities and that the yields of biomass boilers are lower than conventional boilers.

The high annual production of ash from the boilers, generates expectations for a possible recovery in the forest as a fertilizer derived from moderate liming and fertilizing capacity of the same and suggests an important avenue of appreciation of this waste, and improvement in practice the establishment and nutritional status of forest plants [24], significantly improving the porosity of the soil, water holding capacity.

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