Energy Efficiency in olive oil Mills

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Introduction

In Portugal between 2009 and 2011 the planted area of olive groves has increased which led to installation of new olive oil mills and the modernization of existent ones, from traditional to three-phase and two-phase olive mills and more efficient extraction processes. In 2011 there were 527 olive oil mills, being 138 cooperatives (INE, 2012), representing 30% of the total olive oil production (GPP, 2013). According with data recorded by INE in the annual industrial production survey of 2011, based on 123 Portuguese olive oil mills analysed, olive mills energy consumption is based mainly in electricity (98,3%), with low contribution for biomass, diesel and gas, with values of 1%, 0,5% and 0,2%, respectively.

Spain is the biggest olive oil producer in the world, with average annual productions around 750.000 tons, and with a maximum of 1,4 million ton. The area of planted olives has increased in the last years, and has now more than 300 million olive trees, that occupied an area of about 2,5 million hectares, representing more than 25% of the world area planted with olive trees (ASOLIVA), and 50% of the EU-27 planted area (EUROSTAT). It is one of the most important crops in the country, which in a few decades has become a pioneer in research and technology development of the olive sector. In accordance with OSCAE 2009 (Cooperativas Agro-alimentarias), FIAB 2008, and MARM 2009, there were 1.744 olive mills in Spain, being 951 of them cooperatives.

In the last years, energy efficiency and energy saving measures are objectives of European countries in general and also for the agro-food industry. Improving energy efficiency will contribute to reduce GHG emissions and production costs. Olive oil mills are an example of the agro-industries that have presented a positive evolution with modernization and technological adaptation in the last decades, in order to respond to hygiene and environmental requirements. The improvements in environmental performance in the production of agro-food products are linked to the energy use performed during crop management, food manufacturing and distribution. It is well-known that the main factor for CO_2 emissions during the agro-food industrial processes is energy consumption. In addition, agro-food producers are very aware of the importance that international markets give to food products' carbon footprint, and to the decreasing trend of it.

In olive mills the general production process consists in olives reception, cleaning and storing, grinding and paste homogenisation, phase separation, storage and bottling. The major source of energy for olive mills operation is electrical. In fact, from the olives reception until bottling, all machines work based on electricity. Hot water is also used, heated in a boiler that burns olive solid residues, diesel or other type of biomass.

The TESLA project financed by the European Commission under the framework of the Intelligent Energy Europe programme, has the main objective of extend the best available practices for the evaluation of the energy situation and for the adoption of improving measures amongst the European SMEs on the agro-food sector. TESLA project is focused on the agro-industry cooperatives of wineries, olive oil mills, animal feed factories, and fruits and vegetables processing plants. Cooperatives, universities and research centres from Portugal, Spain, Italy and France are partners in this project.

The main objective of this work is to present the results of energetic analysis conducted in Portuguese and Spanish olive oil mills and to explore the results in order to find the critical points of energy consumption and to present alternative measures that could improve energy efficiency use.

Methodology

Typical energy values were analysed in two types of mills with different production volume. Mean values are for industries processing capacities of 1.600 and 300 tons of olive oil per year (both two-phase oil decanter and biomass boiler). Olive oil mills have a clear seasonal activity: from November to March. Information about equipment characteristics, namely power installed, energy consumption and quantity of olives processed was recorded in olive mills in Portugal and in Spain. These olive mills are considered as showcases that will be used to analyse energy consumption during the different production process.

Results

Tables 1 and 2 show the average values of standard production for industries sizes of 1.600 and 300 tons of olive oil per year, respectively.

Table 1. Values of a standard production process, industry of 1.600 tons of olive oil per year, from an analysis of six olive oil mills (Cooperativas agro-alimentarias, 2010).

		VALUES OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**Electrical power installed (kW)**	**Electrical energy consumption (kWh/year)**	**Thermal power installed (kW)**	**Thermal energy consumption (kWh/year)**
Olives reception, cleaning and storage	Electrical motors	750	21.000		
Mill and paste preparation	Electrical motors, biomass boiler	400	93.000	870	270.000
Separation of phases (decanter) and centrifuge	Electrical motors of the two phases decanter	170	120.000		
Storage	Electrical motors, biomass boiler	170	12.000	200	26.000
Bottling	Electrical motors	70	4.000		
Lighting and other electrical auxiliary processes	Fluorescents	40	38.000		
Thermal auxiliary processes	Heating boiler, forklifts			260	40.000
TOTAL		1.600	288.000	1.330	336.000

Table 2. Values of a standard production process, industry of 300 tons of olive oil per year, from an analysis of the University of Évora of a representative olive oil mill

		VALUES OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**Electrical power installed (kW)**	**Electrical energy consumption (kWh/year)**	**Thermal power installed (kW)**	**Thermal energy consumption (kWh/year)**
Olives reception, cleaning and storage	Electrical motors	70	3.600		
Mill and paste preparation	Electrical motors, olive pit boiler	100	13.000	*175	50.000
Separation of phases (decanter) and centrifuge	Electrical motors of the two phases decanter	40	12.500		
Storage		0	0		
Bottling	Electrical motors	6	710		
Lighting and other electrical auxiliary processes	Fluorescents	1	1.350		
Thermal auxiliary processes	Heating boiler			*175	10.000

TOTAL		217	31.160	175	60.000

* Thermal power installed is referred to boiler power heating water for both processes (mill and paste preparation and thermal auxiliary processes) which cannot be considered separately.

Concerning the thermal energy consumption we can see in the Tables 1 and 2 that biomass consumption is only used in the boiler to heat water used in the production process or for heating the building offices. In most of the olive oil mills boilers use olive pit as the source of biomass fuel, and in most cases they use the pit obtained during the olive oil production. In figure 1 it is shown the relative contribution of thermal and electrical consumption, and we can see that in the olive oil mills the distribution is approximately half for each component, 54 and 46%, respectively. Some differences can be found between companies in the percentages of energy consumed per process, depending on each olive oil mill processing technologies.

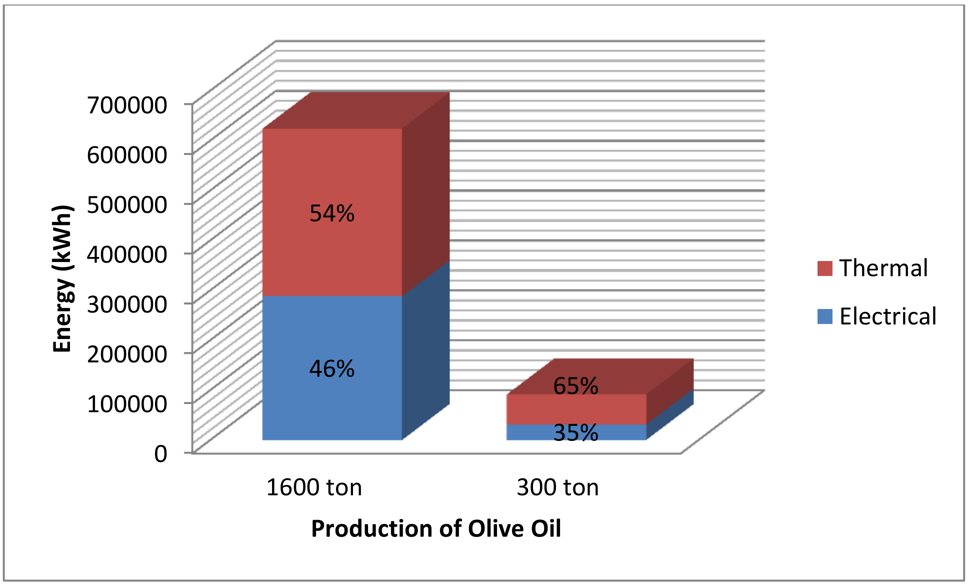

Figure 1 – Relative distribution of energy consumption in olive oil mills

Assuming an average price of 0,10 €/kWh for the electricity and 0,017 €/kWh for the thermal energy we can say that the total energy costs vary between 4.136 and 34.512 € per year for the analysed olive mills, representing a cost per ton between 13,8 €/ton and 21,6 €/ton. Electrical energy represents from 75 to 83% of the total energy costs. However, since most of olive oil mills use their own olive pit residues as biomass for the boilers, thermal energy cost is usually low and related with the olive pit drying and screening. Thus, almost 100% of energy costs come from electrical energy.

Figure 2 shows the energy balance (thermal and electrical energy) using the Sankey diagram for the analysed industries with 1.600 tons of olive oil processed per year. It is possible to observe the relative distribution of thermal and electrical consumption per production phase. Concerning the thermal energy, the higher consume is for the mill and paste preparation while electrical energy is mainly for the phases separation and paste preparation. This shows that measures to improve energy efficiency need to be focused on these production processes. Reception and lighting are also important, using 4% of the total energy consumption.

Results obtained in a case study of an olive mill located in South of Spain, with a production of 4500 ton of olive oil per year, which implemented several measures with the goal to improve energy efficiency, such as replacing motors by more efficient ones, replacing the vertical centrifuges by decanting deposits, installing the Oleosim system, increase pipes thermal insulation, optimize contracted power and implement a solar photovoltaic system, in a total of approximately one million Euros investment, showed an energy saving of 143 kWh/ton and 57,3 kg CO_2/ton of olive oil processed per year.

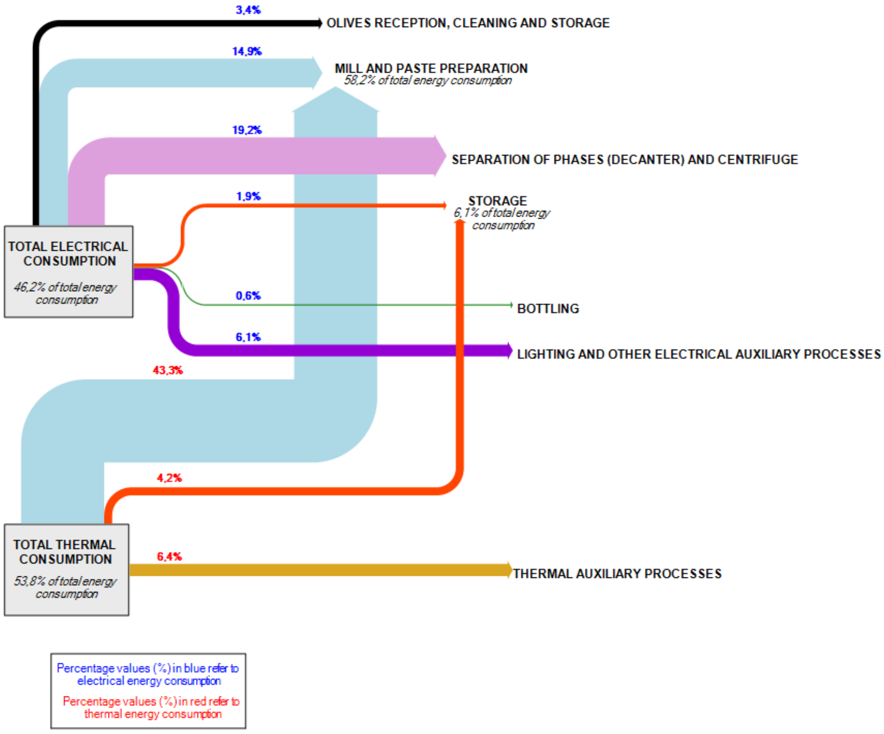

Figure 2 - Electrical and Thermal Energy Balance for the standard production industry of 1.600 tons of olive oil per year (elaborated by Arianna Latini, ENEA)

Conclusions

In olive mills, it is necessary to optimise energy consumption and with that energy efficiency will be improved and will also contribute to reduce energy costs and GHG emissions. With the study of the energy consumption along the several production phases and with the knowledge of the energy balance, it is possible to identify critical points and to use suitable techniques.

In olive oil mills it is possible to improve energy efficiency essentially with some interventions in the equipment, lighting, automation, and the use of olive pit as biomass fuel for the boilers. Also the use of insulating material in the pipes that transport hot water can minimize heat losses and decrease energy consumption. Another important aspect is to use equipment correctly designed and adjusted for the production volume, improving the production system functioning and saving energy. Finally a correct and frequent maintenance of the equipment is also very important to save energy.

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