Applied Mechanics and Materials Vol. 590 (2014) pp 878-882

doi:10.4028/www.scientific.net/AMM.590.878

Characterization of the Specific Electrical Energy Consumption of Agrifood Industries in the Central Region of Portugal

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Keywords: Energy consumption, Agrifood industry, Refrigeration systems.

Abstract. This paper provides a characterization of the electrical energy consumption of agrifood industries located in the central region of Portugal that use refrigeration systems to ensure the food safety. The study is based on the result analysis of survey data and energy characteristics of the participating companies. The agrifood industries included in the survey belong to the following sector: meat, dairy, horticultural, distribution and wine. The comparison of energy indicators for the specific electrical energy consumption of companies of a sector and between sectors is analysed and discussed, providing reference levels for the energy performance of agrifood industries. Since the agrifood sector accounts for high level of energy consumption, the energy performance level knowledge can promote the rational use of energy as well as helping on the decision making of practice measures for the improvement of the energy efficiency.

Introduction

The current demand for energy has reached alarming proportions, severely affecting the sustainability of the planet. This context fits the relevance of studies that allow the reduction or rationalization of energy consumption [1].

The importance of the agrifood industry in this context is related to its significance in business development and to the continuous energy consumption by the cooling systems to ensure food safety, making this sector one of the largest energy consumers.

There are several studies and guidelines on energy efficiency and sustainability, such as the Green Paper [2] of the European Communities. Additionally, some European project are aimed to promote these conditions along the food cold chain such as FRISBEE (Food Refrigeration Innovations for Safety, Consumers Benefit, Environmental impact and Energy) project [3]. It provided new tools, concepts and solutions for improving refrigeration technologies along the European food cold chain. The mathematical modelling tools combine food quality and safety together with energy, environmental and economic aspects to predict and control food quality and safety in the cold chain. The ICE-E (Improving Cold Storage Equipment in Europe) project [4-5] provided information and tools to cold store operators, designers and users to help them reduce the energy consumption and carbon emissions from the European food cold storage sector, through the application of energy efficient equipment choices. Also, the Chill-on project [6] was developed to improve the quality and safety, transparency and traceability of the chilled/frozen supply chain by developing cost-effective technologies, devices and approaches for continuous monitoring and recording of the relevant data and processing the data for information management throughout the entire supply chain. The scientific research has also dedicated efforts to improve energy-related problems in refrigeration systems of agrifood companies such as the evaluation of energy consumption levels, barriers and benefits of implementing food security management systems, development of eco-efficiency indicators to qualify companies performance, power management method in the sector, the results of resource efficiency in companies, local food retail chains as method of energy reduction, among many others [7-11].

At a Portuguese level, the Portuguese Federation of Agrifood industries is engaged in strategies, rules and various types of investments in the development of the sector. There some national projects to evaluate and promote energy efficiency measures applicable to the Portuguese industry. The InovEnergy project is the most relevant in this context since it is directed to the identification of energy consumption profiles in the agrifood industry. Additionally, it intends to promote and develop actions that contribute to a real improvement of energy efficiency and competitiveness of this sector [12-15]. The work developed and presented in this paper is part of this project results. This paper characterizes the energy consumption of agrifood industries located in the central region of Portugal, analysing the energy intensity (EI) and the specific consumption of electricity (SCE) in six sectors – meat, dairy, horticultural, distribution, fish and wine sectors– as well as performing the comparison between the industries of each sector. It aims, after a detailed energy analysis to reported companies, to identify practice measure necessary to correct unfavorable practices and inefficiencies, in order to improve the energy efficiency of the agrifood industry.

The Portuguese Agrifood Industry

The agrifood industry is the manufacturing industry that most contributes to the Portuguese economy (14 billion euros), representing nearly twice the volume of the second manufacturing industry, the metallurgical. It is also the industry that invests most in Portugal, and the second manufacturing industry that generates more employment (about 16%). This sector is crucial to the growth strategy of the country, with direct contribution to exports increase. This sector has the capacity to ensure food self-sufficiency and still is one of the greatest potential for growth in production levels and turnover compared with European counterparts [16]. Currently the agrifood industry represents 25% of the total Portuguese industry. After the accession of Portugal to the European Union, the construction of the single market in 1993 forced the agrifood industry to an effort to harmonize rules of handling, manufacturing and displaying, namely the rules for labeling, hygiene, safety and additives. The relationship between industry and production and between industry and universities has driven the development of a more competitive international industry.

Energy Efficiency Relevance in the Agrifood Industry

The increasing use of energy worldwide raises concern given the scarcity of energy resources and the serious impacts on the environment (climate change and global warming). Recently, it was observed that in developed countries, energy consumption of residential and commercial buildings has increased its contribution from 20% to 40% of global energy consumption, surpassing the industrial and transportation sectors. Thus, it is expected the increase of energy demand as result of population increase, demand for services in buildings, and requirement of comfort levels. Given these considerations, the building energy efficiency becomes a primary goal in national and international policies energy. The current Portuguese economic situation as well as the requirements imposed regarding the high consumption of energy resources for production and distribution of final energy, lead to a concept of energy efficiency that has been expanded in the literature for the applicability of measures leading to optimize the energy cycles (production and distribution) as well as the rational use and conservation of energy, which in the case of industries translates into using less energy and get the same energy value, i.e. at least obtain the same amount of final product.

The energy intensity (EI) of an industry relates the final energy consumption to the gross value added, being strongly associated with the type of industry and level of technological development, resulting in an economic efficiency index. The other economic index is the specific energy consumption (SEC) which is the quotient of the total energy consumption and the amount of final products, in which variations in the production process and type of equipment used between companies can lead to different values of this parameter. The smaller the values of these indicators are, the greater the energy efficiency of these industries.

Power consumption in Portuguese manufacturing industries is still a factor to be improved in many aspects such as proper maintenance of premises to an upgrade or renovation of equipment,

encouraging practices measures of energy efficiency. In the particular case of agrifood industry, the energy consumption can reach high values due to the food products processing, but mainly for their cold storage process. Refrigeration of cold stores is responsible for about 60-70% of electricity consumption of these facilities [8-9].

Materials and Methods

In order to assess the Portuguese panorama of energy consumption in agrifood industry and what should be the action points that would foster energy efficiency strategies, surveys and audits were performed to agrifood companies located in the central region of Portugal. In the region of Beira Interior Norte was considered a sample of 39 companies, 9 companies of the meat sector, 8 companies of the dairy sector, 6 companies of the horticultural industry, 7 and 9 companies of distribution and wine industry respectively. The gap between the number of companies in each sector highlights its importance in the region under study as well as the willingness of companies to participate in the study. The characterization of companies was performed by sector and by industry, relying on the following topics: (1) General company information such activity, location, covered area, classification of economic activity, and quantitative information of raw material and final products, supplies and energy consumption; (2) Technical data collected on the facilities and equipment as cold stores features (size and layout), refrigerants used, heat transfer fluids, compressed air systems and energy efficiency measures; (3) Documents provided by companies like plant facilities and flowchart of production processes and/or storage; (4) Additional information about a previous analysis of energy efficiency, in terms of inefficiencies found in equipment and facilities. Table 1 shows the range (minimum to maximum) of annual general indicators per sector. Note that in the horticultural and distribution sectors, the amount of raw materials and final products is the same, because these companies do not have their own production process, working only as warehouses.

Table 1. Range (minimum to maximum) of general indicators per sector

Sector	Employees	Business volume (10^3€/year)	Raw material (ton/year)	Final product (ton/year)	Electricity (MWh/year)
Meat	4 - 48	250 – 8000	42 – 4466	27 – 3349	38 – 1014
Dairy	6 -31	130 – 6000	140 – 1500	25 – 1322	27 – 1454
Horticultural	2 - 26	200 - 2500	400 - 4650	400 - 4650	25 - 1025
Distribution	9 -67	500 - 12500	30 - 2500	30 - 2500	136 – 1027
Wine	1 -22	50 - 4687	50 - 13000	33 – 9750 [kl]	9 - 230

Results Analysis and Discussion

In order to evaluate the national panorama and identify the practice measures that promote energy efficiency strategies, surveys and audits data was obtained, crosschecked and analysed. Figure 1 is shown the maximum, average and minimum values of energy intensity (EI) for each agrifood sector. All sectors present good values, being the largest value of EI detected in the horticultural sector. This sector has also the widest span of EI values. In the list of companies analyzed in this sector, the majority is classified as small and medium enterprises. In some companies, it was found that the number of employees is not commensurate with the turnover. On the other hand, the distribution sector has lowest EI value. This sector has, notably, the highest turnover, and its energy consumption is exclusively electricity for companies that work as warehouses. Comparing the values of EI presented by the meat and dairy sectors with specific production processes and different production throughout the year, it is shown that the meat sector consumes less energy due to lower losses of raw material during the production process and higher business volumes.

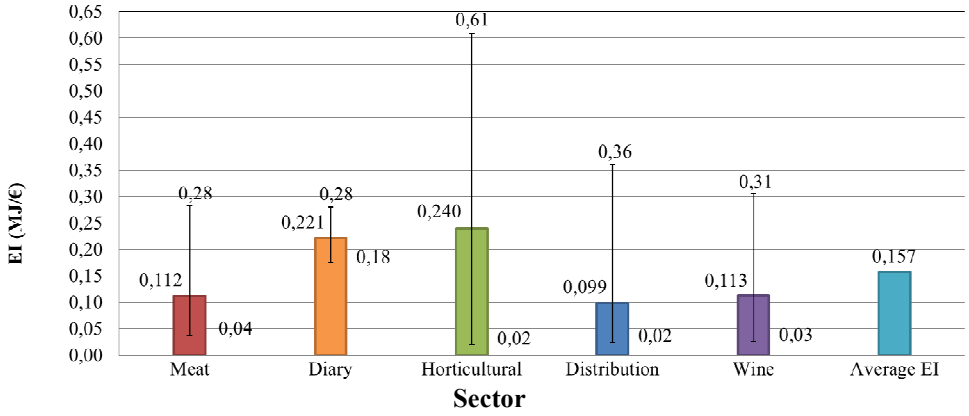

Figure 1. Range of energy intensity (EI) per agrifood industry sector

Fig. 2 shows the specific electricity consumption for the selected agrifood industries. For this energy indicator it is shown that the dairy row has the highest SEC value. This sector shows the largest difference between amount of final product and raw material for similar values of energy consumption of other sectors. On the other hand, shows the wine sector presents the lowest SEC value, since the amount of energy consumed by refrigeration systems is lower as production is seasonal, lasting approximately 2 to 3 months. The horticultural sector presents the second lowest SEC. This sector has lower average value of energy consumption than other sector for the same products quantity. The distribution sector has the second highest value and larger dispersion.

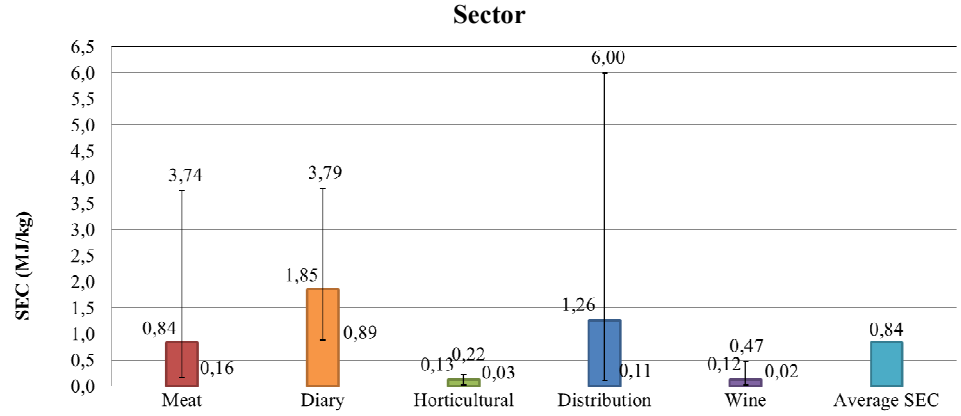

Figure 2. Range of specific electricity consumption (SEC) per agrifood industry sector

Conclusions

The results from surveys and audits performed to a set of agrifood industries located in central region of Portugal (Beira Interior Norte region), characterizes the energy panorama of agrifood sectors allowing to deduce the energy performance of this sector in this region.

The range of values of EI and SEC among sectors is notorious and reveals that companies with the best indicators are able to positioning themselves better in the market. The assessment of the energy consumption in agrifood sector reveals the need to continue the research in this topic, both in logistics and production strategies, both in implementing structural actions as different electrical consumption according to peak hours or changing slightly the temperature in cold rooms without compromising product quality and safety in order to improve the energy performance of these companies and hence their competitiveness.

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