



ANALYSIS OF ENERGY USE AND POSSIBILITY OF IMPROVING ENERGY EFFICIENCY IN GOAT FARM-DAIRY "BEOCAPRA", SERBIA

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Abstract: Nowadays people face challenges of rising energy consumption, energy costs, environmental impacts, consequence of global warming etc. All trends are directed to reduce those negative effects. In terms of energy consumption, the main goal of any production is to reduce energy consumption per product unit. At the goat farm and dairy Beocapra, located in Kukojevci in Serbia, energy was used for technological processes that include heating and cooling different types of working mediums as well as for heating and cooling spaces of the dairy. In this article the structure of used energy, energy quantities, temperature regimes and quantities of mediums and power consumption of the biggest systems were presented. The measures for improving energy efficiency and possibilities of using renewable energy sources for covering a part of energy demands were proposed. At the end of the article benefits of using proposed renewable energy sources were given.

Key words: energy, dairy, energy efficiency, renewable energy sources

1. INTRODUCTION

Milk production is the largest sector within Serbian agriculture, bearing in mind the fact that it accounts for 7.92% of the value of agricultural production (average 8.12% for 2008-2013) 1.. However, the analysis of the market from 2008 led to the data that only 0.4% of the total amount of milk produced was given by goats. If this figure is compared with the average 3-5% in EU countries, it is clear that Serbia is an excellent ground for significant progress in the development of dairy goat breeding. The fact that the dairy industry in the Republic of Serbia is one of the strongest food industries, not only in the country, but also in the region, should be added to this.

Increasing the economic profitability of agricultural production can be achieved by reducing the share of energy costs within the direct production costs of certain agricultural products. In the field of milk production and processing, this can be achieved, among other things, by using highly efficient systems that use renewable energy sources for their work. On the example of the company "Beocapra" from Kukujevci, which is the leading company from Serbia in the field of goat breeding and production and processing

of goat milk, an analysis of the energy use on an annual level in the production process of the dairy was conducted. The measures to improve energy efficiency, which are based on the use of solar energy in the milk production process, have been proposed.

2. DESCRIPTION OF GOAT FARM AND DAIRY COMPANY "BEOCAPRA"

The company "Beocapra d.o.o." is founded in 2009. The company's headquarters are located in the village of Kukujevci, Šid municipality, about 100 kilometers from Belgrade. At this locality, on the land owned by the company, with an area of about 4 hectares, there is a farm and a dairy (Figure 1). The farm came to life at the end of 2009, when 179 goats and 5 billy goats of the San breed were imported from Austria. The plant for processing raw goat's milk and production of dairy products started operating in November 2010.



a) A facility for housing and feeding goats



b) Dairy

Figure 1. Goat and dairy farm of the company "Beocapra"

"Beocapra" farm, which covers an area of about 3000 m², includes facilities for housing and feeding goats and kids, automated milking, as well as auxiliary facilities for goats, storage of bulky food and manure disposal. The construction of the facility is based on a detailed conceptual and technological project. A concept based on a central feeding corridor with laterally placed boxes for housing animals has been implemented, which is otherwise very rarely used in goat breeding facilities in our country. This concept provides enough accommodation (about 1.75 m² per head), as well as the optimal diet. Vertically movable, automatic curtains are placed along the entire length of the barn walls, which provide quality ventilation of the space. The milking parlor is completely automatic, with the measurement of the amount of milk at each milking place and with the collection of milk in a closed milk freezer. For the nutrition of goats, only the highest quality raw materials are used, such as dried alfalfa, ensiled alfalfa and corn, specially prepared concentrate, that is, mixtures of cereals and prekims, etc. Most of the animal feed "Beocapra" produces or prepares itself, while the rest is procured from proven producers.

Milk processing plants are based on modern solutions, respecting the basic principles of material and human flow. The entire facility is built of quality sandwich panels made of plasticized steel, while the floors are made of the most modern BASF masses, all in order to meet all the requirements of the food industry. Maintenance of the entire production plant hygienic regime - washing and cleaning of pipelines, tanks, milking devices, pumps, freezers and other process equipment, is carried out without its dismantling using an integrated CIP (Cleaning In Place) system. After receipt, sterilization, homogenization and pasteurization of milk is performed, after which its part is used in further production of sour-milk products. The dairy has three cold stores that are used during certain production processes, as well as for storing finished products. Since they operate in different temperature operating modes, three separate refrigeration plants have been used to provide them. Ventilation of the dairy production part is done with the help of an air chamber. The complex process pipe distribution with fittings provides distribution of hot and cold water for the needs of production, as well as warm water for the operation of the CIP system. Industrial steam is provided for the purpose of labeling bottled products. The production and office part of the dairy, with a total area of about 600 m², is equipped with an electrical installation for lighting, in the form of LED bulbs, as well as an electrical installation for the operation of all machines and electrical devices.

"Beocapra" also took care of the maximum possible saving of natural resources. Therefore, the dairy is equipped with a water-to-water heat pump, with a power of 10 kW, which, in conjunction with fancoil heat exchangers, is used for heating and air conditioning of office space. At the same time, water is supplied from the pumping well of the heat pump, with a depth of over 100 meters.

The capacity of the dairy at this moment is 4-5 thousand liters of milk, with work in two shifts. Since the possibility of automation of all processes is left, with relatively small investments, a significant expansion of capacity is possible. "Beocapra" has certificates on the implementation of quality management systems required by international regulations.

KOZARI is a brand under which "Beocapra" produces and sells top quality goat milk products, such as: probiotic drink "miracle", yogurt, pasteurized milk, whey, white cheese in slices, smoked cheese, cheese in olive oil, cheeses with molds and accessories, etc. (Figure 2).



a) Company logo



b) Some of the products of the brand KOZARI

Figure 2. Goat milk production program of the company "Beocapra"

The work of the company "Beocapra" is based on the business of feeding and reproduction of goats, milking, collection and processing of raw milk, production of premium goat milk products, and bookkeeping, commercial and distribution. The company's goal is to use other resources and "by-products" of goat breeding. The plan is to build a plant for the production of goat humus, as well as to establish cooperation with the meat processing industry.

3. ENERGY USE ANALYSIS

The farm and the dairy use two basic energy sources - electricity and liquefied petroleum gas (LPG gas). The farm is supplied with electricity from the low voltage network, and LPG gas is delivered by tanker truck and stored in a tank on the farm. In the office part, for the needs of heating and air conditioning, through the heat pump, geothermal groundwater energy is used as a renewable energy source.

LPG gas is an energy source for the operation of a hot water gas boiler with a power of 250 kW. Its operation provides hot water with a temperature between 97-98°C, required in technological processes during the production of milk and dairy products (Figure 3).



Figure 3. Part of the dairy production plant - line for thermal processing of milk

When it comes to the electricity use, in addition to the above (process devices for milk production and processing, pumps, compressors, ventilation system, lighting, mills for preparing animal feed, milking system) is used to drive an electric steam boiler, power of 45 kW, in order to produce saturated water vapor pressure of 1.8 bar (water vapor saturation temperature is 116.93°C). The produced steam is used in the packaging of bottled products (Figure 4) for the process of gluing slip labels.



Figure 4. Part of the dairy production plant - bottled product packaging line

Heating of the warm water for the CIP system needs, as well as preheating of the feed water for the electric boiler, is done at the expense of condensation heat recovery that occurs during the operation of refrigeration plants. In addition to the listed refrigeration plants that are used to maintain the temperature in the cold stores, the dairy also has a refrigeration installation with a pool of ice water, necessary for the production process. The process cold water temperature is 1-2°C.

The amount of energy used on an annual basis, determined on the basis of monthly electricity bills and data on the amount of LPG gas delivered, is shown in Figure 5.

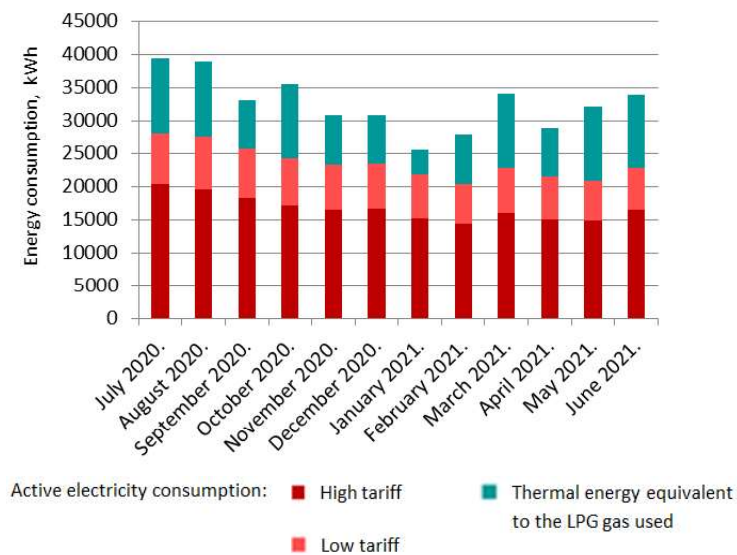


Figure 5. Consumption of basic energy sources on the farm and in the dairy on an annual basis

Based on the analysis of used LPG gas and active electricity, it can be concluded that the amount of energy used during the year is variable. The maximum consumption of electricity, which was recorded in the summer months, comes from the more intensive operation of ventilation and air conditioning systems, i.e. refrigeration systems due to the greater need for cooling. During the winter months, there is a slight decline in energy use due to reduced production - gas consumption is lowest in January and active electricity consumption in February.

The amounts of energy used per unit of raw material, i.e. specific energy used in the dairy industry, which indicate the degree of plant efficiency, are shown in Table 1. The value of this specific energy represent the ratio of the total energy used for production of a certain dairy product and the amount of processed milk, as input raw material for the production process.

Table 1. Specific energy used in the dairy industry 2.

Reg. no.	Dairy product	Specific energy used	Unit
1.	Drinking milk	0.1 – 0.6	MWh/t of processed milk
2.	Cheese	0.1 – 0.22	
3.	Fermented milk	0.2 – 1.6	

As the "Beocapra" dairy produces all three of these dairy products, as the recommended value of the energy amount used per unit of processed milk, the average value was adopted, which ranges from 0.1 to 0.8 MWh/t of milk.

Figure 6 shows the specific energy used by the dairy on a monthly basis. It is important to note that the displayed values are not measured, but it is an estimated value. The dairy has monthly reports on the amount of processed milk and that information is known. The total energy used for the production process in the dairy is the sum of the estimated active electricity and thermal energy equivalent to the LPG gas used. The value of electricity used in the dairy was obtained by subtracting from the total electricity used on a monthly basis the estimated amount of electricity used on the farm for animal husbandry, which is one third of the total active electricity used 2..

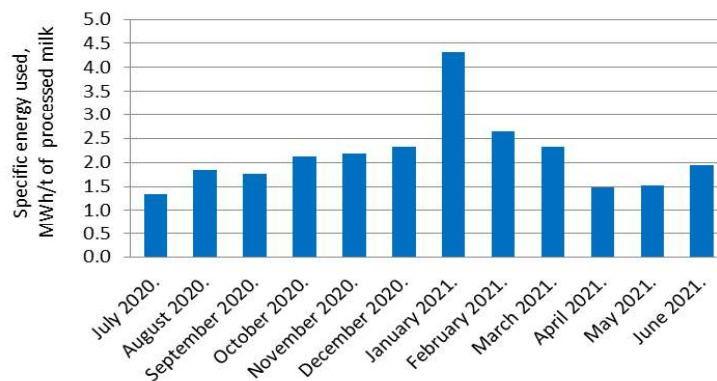


Figure 6. Specific energy used by the dairy on a monthly basis

Based on the analysis of the presented values, it can be concluded that they are above the upper limit of the prescribed values of the specific energy used in dairies, and range from 1.3 MWh/t of milk in July 2020 to 4.3 MWh/t of milk in January 2021. These deviations are most significant in the period from October to March, which is a consequence of the reduced volume of production in that period, i.e. the reduced amount of processed milk. At the same time, the reported monthly values of the energy used per unit of processed milk suggest that there is a significant potential for energy savings.

4. POSSIBILITY OF IMPROVING DAIRY ENERGY EFFICIENCY

As already mentioned, the company "Beocapra" took care of the maximum possible saving of natural resources, which is why the dairy is equipped with a geothermal heat pump for space heating and air conditioning. Among other things, the operation of the ventilation system is largely optimized. Ventilation control is automatic and is performed according to the outside temperature. Object lighting is also optimized. LED lamps are used, which are periodically replaced during regular maintenance. Nevertheless, there is room for further energy savings.

Based on the temperature regimes of hot water used in technological processes during the production of milk and dairy products (hot water temperature is between 97-98°C), it can be concluded that there is a huge potential for the application of solar thermal collectors. The use of solar collectors with vacuum tubes would be optimal 3.. Their application would simultaneously provide heating of water for the operation of the CIP system, as well as preheating of water that goes to the electric steam boiler. For the purposes of this paper, an analysis of the use of solar energy for heating was performed. The sizing of the solar system was carried out in such a way that in July it fully covers the needs for thermal energy, which is equivalent to the LPG gas used and about 30% of the electricity used for thermal needs. The analysis was conducted by months for the climate data of Belgrade 4., for selected solar vacuum collectors. The *f-chart* method 5. was used in the calculation, which enables the determination of the solar share in the total required thermal energy of the dairy (Figure 7).

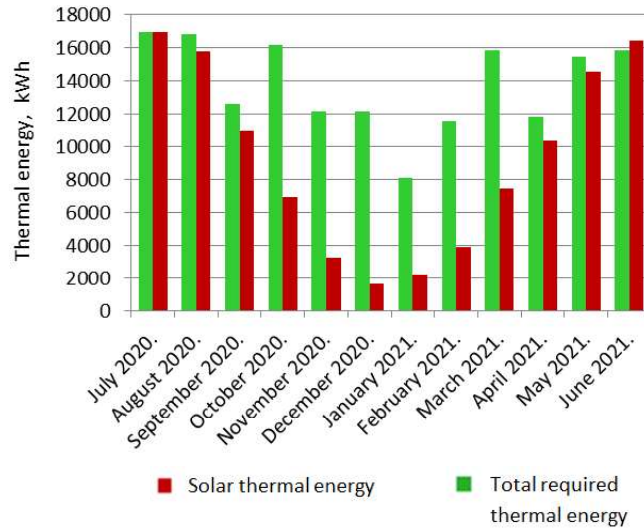


Figure 7. The share of thermal energy of solar panels in the total required thermal energy of the dairy

Figure 7 shows that in the period from April to September, solar thermal energy covers a significant part of the total required thermal energy in the dairy (in June and July in full). At the same time, in this period, it leads to a decrease in the specific energy used by the dairy on a monthly basis, whose values are now in the recommended interval or at its upper limit (Figure 8). The percentage reduction of the specific energy used by the dairy ranges from 7.2% in December 2020 to 62.1% in June 2021.

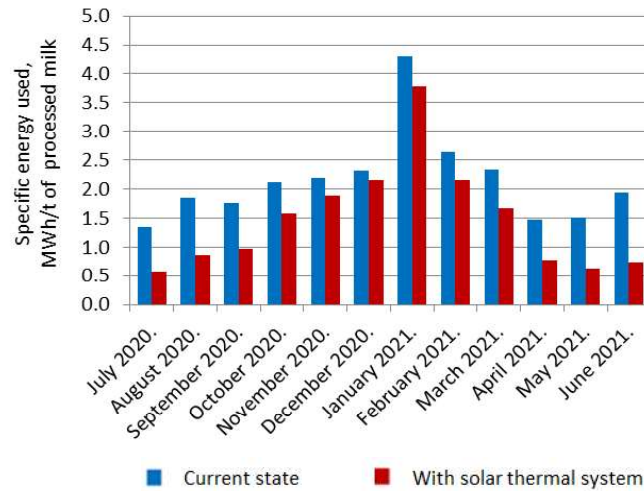


Figure 8. The specific energy used by the dairy on a monthly basis with and without a solar thermal system

The values of the specific energy used are more than recommended in the period from October to March. This suggests that an additional part of the active electricity used should be replaced by a system that uses renewable energy sources for its production. For these purposes, the use of solar photovoltaic collectors would lead to a further increase in the energy efficiency of the milk and dairy products production.

5. CONCLUSION

On the example of the company "Beocapra" from Kukujevci (Šid), which is the leading company from Serbia in the field of goat breeding and production and processing of goat milk, an analysis of energy use on a monthly basis during one year was conducted. The farm and the dairy use two basic energy sources - electricity and liquefied petroleum gas. The amount of energy used during the year is variable. The maximum consumption of electricity was recorded in the summer months, due to the more intensive operation of ventilation and air conditioning systems, i.e. refrigeration systems due to the greater need for cooling. During the winter months, there is a slight decline in energy use due to reduced production. The amount of energy used per unit of processed milk is above the prescribed values for the dairy industry, which suggests that there is potential for energy savings. The application of highly efficient solar thermal and photovoltaic systems would lead to a significant increase in the degree of energy efficiency of the milk and dairy products production.

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