ECONOMIC ASPECTS OF PRODUCTION OF FUEL BRIQUETTE FROM AGRO BIOMASS

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Summary: The article on the background of in-depth analysis of the significance and development of renewable energy sources, examines the technologic and logistic processes of the companies producing fuel briquettes from agro biomass. This analysis, was extended by the calculation of the cost of the discussed product production process. On the basis of the research conducted in the enterprise, the total cost of producing the ton of fuel briquettes from straw was estimated at the level of 254.3 PLN and at the level of 344PLN for briquettes produced from sawdust. The study highlighted the problem of exploitation of raw material insufficient for qualitative reasons (in this case – moisture content over 20%). It was shown that it impedes the technologic and logistic processes within the production system, and moreover increases production costs by more than 19%.

Keywords: fuel briquettes, constant biomass, agroenergetics, production costs, renewable energy sources.

1. Introduction

Over recent years, within the European Union, a comprehensive package of actions has been approved, to prevent climate change [4] and to provide Europe with a reliable and sufficient energy supply. The package, which is the most far-ranging reform of the European energy policy, aims to guarantee the global leadership in the field of renewable energy and low-carbon technology. Due to the European Union environmental commitments, the following indicative targets are intended to be achieved: reducing the greenhouse gas emission by 20%, reducing energy consumption by 20% in comparison with the projections for the EU in 2020, and increasing the share of renewable energy sources (RES) to 20% of the total energy consumption in the EU.

Many sources point the fact, that taking into consideration the geo-climatic conditions of Poland, the most important renewable energy source is biomass, and that its use in the coming years will increase [3, 9, 10, 11]. Biomass is used for energy purposes in the process of direct combustion (wood, straw, energy crops), converted to liquid fuels (such as esters of rapeseed oil, alcohol), or gas (for example agricultural biogas) [9]. According to the data of Central Statistical Office, in 2009 in Poland, 67.3 Mtoe of primary energy was obtained, of which 6.0 Mtoe, that is about 6%, was the energy from the renewable sources. More than 86% of this was obtained from the most important renewable energy source in Poland – solid biomass.

Solid biomass includes organic, non-fossil material of biological origin, which can be used as fuel to produce heat or to electricity generation. The basic solid fuel from biomass is:

– forest biomass (firewood) in the form of chunks, round timber, chips, briquettes, pellets,

- waste from forestry, wood and paper industry, i.e. branches, poles, thinning, shrubs, brush-wood, root wood, bark, sawdust, black liquor,
- a separate group consist of agricultural biomass fuels from energy crops (fast-growing trees, dicotyledonous perennials, perennial grasses, energy cereals),
- organic remnants from agriculture and horticulture (e.g. wastes from horticultural production, animal manure, briquettes and pellets of straw, etc.).

The need to increase energy production from renewable sources in Poland and in the European Union, leads to an increase in demand for agricultural raw materials used for energy purposes. Increased demand for these products has a significant effect on agricultural and energy markets, and moreover it changes scope and intensity of agricultural land use [1]. Nowadays, there is public discussion about what is the possible use of agricultural resources for energy purposes, and how to use them so as not to adversely affect biodiversity and food security. According to Gorecki and Stolarski [5, 7] a new section of the economy emerges, it is called agroenergetics and:

- will be the main source of acquisition and production of renewable energy in Poland,
- will improve national energy security and the fulfillment of international obligations concerning the environmental protection,
- will determine sustainable, economic and social development of rural areas.

Agroenergetics development requires, among others selection of energy crops, improving crop technology, harvesting technology and methods of converting biomass. The most important way to convert biomass in Poland is a thermo-chemical conversion by combustion. An important type of biomass, used by energy and heat manufacturers are biomass briquettes and pellets from agricultural sources (agro biomass). Also noticeable is the increase in demand for this type of products among consumers, who use them as fuel. Thanks to this situation, the number of manufacturers of briquettes and pellets in Poland is still growing.

2. Purpose, scope of work and research method

The main aim of this work is to estimate the cost of production of fuel briquettes made from different types of solid biomass. The study was conducted on the basis of the data and the production process in the company Ekonika. The study analyses the cost of production of fuel briquettes manufactured from grain and rapeseed straw, which is the remnant of agricultural production, and which use for energetic purposes steadily increases, and also on the basis of sawdust. In addition, the work attempts to assess the impact of too high biomass moisture on the production costs of biomass briquettes. Moisture of briquetted material is an important factor influencing the technologic and logistic processes within the discussed production system. In the interviews with the representatives of the four companies involved in the manufacturing of the discussed product, this factor was designated as one of the most problematic aspects of the production. Furthermore, for the purpose of this work, the necessary information concerning applicable production technology and operation of a processing line for production of briquettes, have been established. The economic and technologic aspects of production of briquettes, presented in this work, may be used in planning this type of production, and also provide information helpful in more efficient management of similar production.

3. Fuel briquette production process and product characteristics

Compacting or otherwise densification of biomass (through briquetting, pressing or pelleting) is performed, due to its unfavorable physicochemical properties, which hinder its use for energy purposes. This is due, among others with too low bulk density of biomass, which makes it difficult to transport, storage and dispensing for boilers. In addition, a wide range of moisture, hygroscopic properties and low calorific value per unit volume cause difficulties in the distribution of biomass in the primary (original) form. Through the use of the above-mentioned processes, which are subjected to biomass, increases its density, water content decreases and increases the concentration of energy per unit volume of biofuels. Almost every type of solid biomass can be subjected to a process of palletizing or briquetting. Straw and sawdust used for energy purposes must meet specific thermal and technologic requirements. Straw quality is determined primarily on the basis of calorific value, moisture content and degree of withering. The main parameters of thermo-physical are the calorific value and heat of combustion. They depend mainly on the chemical composition and moisture content of straw. The heat of combustion is the amount of heat gained during the combustion of solid fuel units in the oxygen atmosphere. Calorific value is the heat of combustion minus the heat of vaporization of water obtained from the fuel in the combustion process and hygroscopic moisture [2].

Production of fuel briquettes consists of the following processes:

- Preparation of raw material - mechanical fragmentation of the biomass using a biomass shredder (depending on the technology used and the type of biomass, can be one or several stages).
- Drying of the shredded biomass fraction (optionally used when the value of the biomass moisture is too high).
- Briquetting of biomass using various types of briquetting machines (for example hydraulic or mechanical). Briquette is formed in the process of pressure agglomeration, in which the loose material by the action of external (compaction pressure) and internal forces (intermolecular forces and bonds) assumes a permanent, geometrical form of defined dimensions [6].

In the production of fuel briquettes, the technological processes are associated with the following logistics processes: external transport of biomass, internal transport of biomass, storage of biomass, packaging and storage of fuel briquettes.

Briquettes have a diameter of several centimeters and generally circular cross-section. Their volumetric mass is about 450 kg/m^3. Briquette as fuel can be used in boiler plants, heating plants, power stations and thermal power stations (both local and industrial), as well as in households by the individual customers. Fuel briquettes are possible to use in most types of fireplaces as well as in conventional boilers burning coal and wood without requiring any modifications. The increase in demand for this fuel is affected, among others rising prices of conventional fuels and increase public awareness of environmental aspects of alternative sources of energy.

3.1. The production costs of fuel briquettes made from cereal and oil-rape straw

Data received from the company were used in estimating the cost of fuel briquette production. Performance of the production system was 350 kg per hour. The raw material used in production was a mixture of cereal (wheat and rye) and oil-rape straw, in the ratio 1

to 1. This is the average production rate obtained when this type of material is used, under the following quality criteria of raw material:

- moisture content below 18-20%,
- appropriate fragmentation of biomass,
- absence of impurities such as stones and metals, which may stop production or in extreme cases, damage machinery and equipment of the production line.

Other issues related to the influence of non-compliance with these requirements at the cost of briquette production, were partly described in chapter 5 of this study. The cost of raw material is the average transaction price per ton of straw which the company bought in 2010. Transport was carried out by own vehicle. Line depreciation period is 5 years. Costs of repairs and maintenance, salaries and electricity were estimated on the basis of historical data from the company.

Tab. 1. Production costs for 1 ton of fuel briquettes from cereal and oil-rape straw

Type of cost	Value per ton [PLN/t]	Percentage [%]
Purchase of raw material	80,0	31,5
Transportation of raw material	15,8	6,2
Depreciation of production line	57,1	22,5
Electricity	51,4	20,2
Repairs and maintenance	11,4	4,5
Labor cost	38,6	15,2
Sum of costs	254,3	100,0

Source: Own elaboration

Total cost of producing 1 ton of briquette amounted to 254.3 PLN, and highest in the share was: cost of raw materials, depreciation and cost of electricity. Briquettes produced in the company for individual customers are packed in plastic bags weighing 25 kg. The cost of plastic bags and packing per one ton of fuel briquette is about 25 PLN.

3.2. The production costs of fuel briquettes made from sawdust

Process efficiency of sawdust briquette production was 400 kg per hor. The price of raw material accepted at the level of 200 PLN per ton based on the experience of the company, and after consideration of the sawdust price and availability in 2010. Furthermore, it is assumed that the raw material at this price meets quality requirements, to the extent that it can be used without additional workload. The price factored the possibility of an additional grinding sawdust to a more fragmented fraction. However, if in the production of briquettes would be used fresh sawdust with a moisture content of about 50%, the production costs will be much higher. This will affect their need for drying, for example, using the drum dryer. Practice is also important to buy uncontaminated sawdust. Mineral admixtures can affect the quality of the obtained briquette. Moreover, it can cause a faster wear of machinery, which increases operating costs. In addition, row-material can be varied in terms of species composition of sawdust, which may affect the performance of existing machinery up to several tens of percent. Similar situation may occur in different types of straw briquetting (compare [12]).

Tab. 2. Production costs for 1 ton of fuel briquettes from sawdust

Type of cost	Value per ton [PLN/t]	Percentage [%]
Purchase and transportation of raw material	200,0	58,1
Depreciation of production line	57,1	16,6
Electricity	45,0	13,1
Repairs and maintenance	11,4	3,3
Labor cost	30,5	8,9
Sum of costs	344,0	100,0

Source: Own elaboration

The total cost of producing 1 ton of fuel briquettes from sawdust amounted to 344 PLN. It is more than 35% higher than in the case of production of briquettes from straw. However, it should be noted that the market price of a ton of sawdust briquette, is also higher than briquettes produced from straw. Lower values of wages and electricity (compared with the case when the material is straw), due to the higher efficiency of the briquetting process. Differences in the structure of the production cost of analyzed products are illustrated one the figure 1.

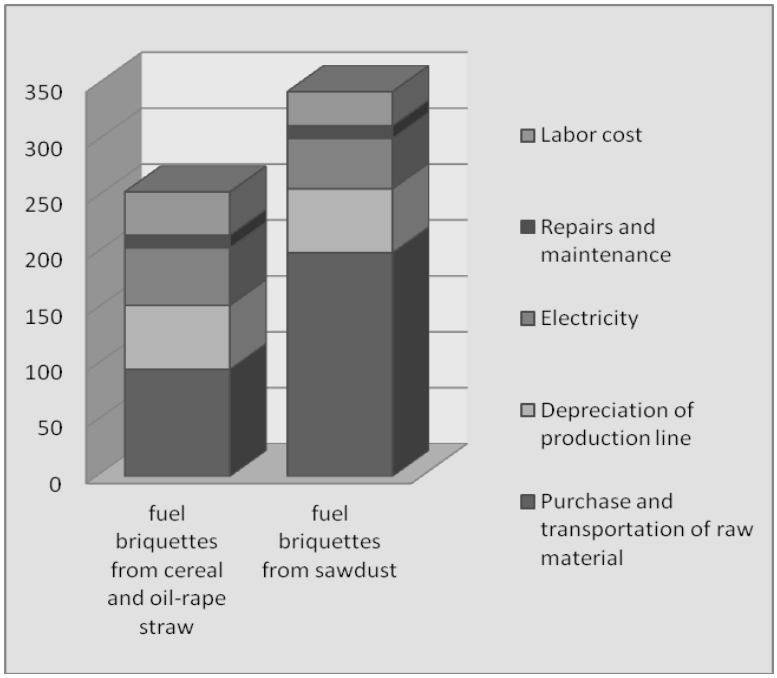

Fig. 1. The production cost structure of the fuel briquettes from various types of biomass [PLN per ton]
Source: Own elaboration

4. The influence of biomass moisture content on the increase of the fuel briquette production costs

The problem of too high moisture content of the raw material can significantly increase production costs. The situation of processing the raw material (in this case, the straw) with exceeded allowable moisture was analyzed. Straw moisture most often occurs as a result of inadequate protection against atmospheric conditions during storage. Particularly affected by this problem is the raw material stored in the form of stacks. The problem of too high raw-material moisture can be solved using the dryers in the production process. However, this solution requires investment, and increases expenditures on production. In Table 3 is a variant of the production with the use of the dryer. In the calculation of the straw drying cost it was assumed. Estimated cost of drying was 40 PLN per ton. The amortization period of the dryer worth 200.000 PLN is 10 years. Efficiency of the drying process is 400 kg of straw per hour.

In the company, during attempts to produce briquette from material with too high moisture, the following consequences were observed:

- The need to manually reject a large part of raw material by the shredder's operator.
- The raw material losses at 15% during the initial stage of the biomass shredding.
- Reduction of the shredding process efficiency by about 10 percent.
- Sudden stopping of the briquetting machine resulting in a significant reduction of the efficiency of briquetting process (from the normal level of 350 kg per hour, up to the level 240 kg per hour).
- There was a lower quality of the produced briquettes (briquette flaking, swelling, increased volume of the briquette, in extreme cases - spill).

Tab. 3. Production costs for 1 ton of straw briquettes in three variants depending on the analyzed factor – straw moisture content

Variants of production		Briquetting of straw at the correct moisture content	Briquetting of straw with too high moisture content	Briquetting of straw with too high moisture content with dryer using
Type of cost		Value per ton [PLN/t]		
Costs depended on the analyzed factor	Material	80,0	92,0	80,0
	Electricity	51,4	75,0	51,4
	Labor cost	38,6	51,7	38,6
	Drying process	-	-	40,0
	Dryer Depreciation	-	-	28,6
Other costs independent of the analyzed factor		84,3	84,3	84,3
Sum of costs		254,3	303,0	322,9

Source: Own elaboration

The range of variability of direct briquette production costs in considered variants (Table 3) is significant and indicates that in the planning of production it is worth to simulate the effects of variable of raw material moisture content on production costs and

effectiveness. Furthermore, it should be noted that a key aspect of managing this kind of production is to prevent raw material from absorbing moisture, mainly while storage, but also during harvest, loading or transport.

5. Summary

The article on the background of in-depth analysis of the significance and development of renewable energy sources, examines the technologic and logistic processes of the companies producing fuel briquettes from agro biomass. This analysis, was extended by the calculation of the cost of the production process of the product discussed. On the basis of the research conducted in the enterprise, the total cost of producing the ton of fuel briquettes from straw was estimated at the level of 254.3 PLN and at the level of 344PLN for briquettes produced from sawdust. The study highlighted the problem of exploitation of raw material insufficient for qualitative reasons(in this case – moisture content over 20%). It was shown that it impedes the technologic and logistic processes within the production system, and moreover increases production costs by more than 19%.

The article emphasizes the close connection between briquette and pellet production and agriculture. Using as a raw material, for this kind of production, remnants from agricultural production and energy crops, helps Poland to fulfill its international obligations concerning the growing importance of renewable energy sources. To summaries results of research agroenergetics development, as it can be observed in Sweden or Austria, seems to be an opportunity to increase profitability of Polish agriculture. What is more it can constitute an important basis for multifunctional agriculture model which can provide Poland food, environmental, and energy security.

Provided results of research may be a useful source of information in the management of companies involved in the production of agro biomass fuel briquettes. Indicating, most of all, that the quality of the material in terms of moisture content is one of the key factors influencing the cost of the production process.

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