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ECONOMICAL ASPECTS OF STRAW BRIQUETTES PRODUCTION

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Summary. The analysis of costs of straw briquettes' energy efficiency has been made. Straw briquetting is attractive mainly in comparison to hard bituminous coal, but only when the straw market prices are low. High straw prices and low grain prices are a threat to briquetting cost-effectiveness.

Key words: briquetting, energy, biomass, grain, costs, production cost-effectiveness

INTRODUCTION

The use of straw for energetic purposes is an alternative for coal combustion. Straw briquetting may be an alternative for pressed straw because of logistic problems (low efficiency of transport means and therefore high transport costs) mainly in case of biomass for the power industry.

The advantage of briquetting is also that the briquettes can be burned in all types of furnaces, and the kinetics of combustion is similar to the combustion of wood chunks. Furthermore, the surface of storage is decreased several times [Demianiuk 2001].

The popularity of straw briquettes depends on the cost-effectiveness of briquetting. Therefore, there is a need for economical analysis of briquetted biomass production.

THE AIM AND SCOPE OF RESEARCH

The aim of research was to evaluate the cost-effectiveness of acquiring energy from straw briquettes, for the needs of individual consumers.

The scope of research included the production costs analysis of four grain plants (winter wheat, winter barley, rye and winter rape), produced in the intensive technology, and the costs of straw briquetting from these plants.

METHODOLOGY OF RESEARCH

The production of winter wheat, rye, winter rape and winter barley, planted in intensive technology, was put under the economic analysis [Chotkowski and others, 1994]. The following crop

was estimated: 4 t · ha^{-1} for rape, 6 t · ha^{-1} for winter wheat and rye, and 5 t · ha^{-1} for winter barley. The estimated crop sizes for calculations were deducted from the assumed level of fertilization and chemical protection [Chotkowski and others, 1994]. The amount of fertilization was estimated for a very good rye soil complex and medium content of minerals in the soil, taking into account the nutritional needs of plants [Chotkowski and others, 1994].

The grain production costs were estimated on the basis of dependency carried out according to the literature [Kalkulacje kosztów... 1998, Klepacki, Gołębiewska 2003]:

$$K_{PROD} = 1{,}1 \cdot \left(K_{NAW} + K_{SOR} + K_{NAS} + \sum_{i=1}^{n} K_m + K_R \right) - D_{BZP}$$

where: K_{PROD} – production costs [PLN · ha^{-1}], K_{NAW}- fertilization costs [PLN · ha^{-1}], K_{SOR}-cost of used pesticides [PLN · ha^{-1}], K_{NAS}- costs of purchases grains [PLN · ha^{-1}], K_R – labour costs [PLN · ha^{1}], K_m – cost of a unit performing a given service [PLN · ha^{-1}], D_{BZP} – direct farming subsidies [PLN · ha^{-1}], n – the number of treatment in a given crop. The costs of tractors and machines exploitation were calculated using the IMBER method [Muzalewski, 1999].

In these analyses, it was assumed that the cultivation of the above-mentioned crops takes place in the conditions of major farms, where tractors and agricultural machines are used very intensively. Therefore, for the calculation purposes, the amortization time for the tractors and machines was assumed to be 6 years. In such conditions, the yearly exploitation of a tractor is about 1600 hours.

The efficiency of the machines and tools was calculated using the methodology and ratios presented in the literature [Lorencowicz 2008].

The data necessary for calculations were gathered from the market (Rynek rolny, 2005-2009) and literature [Harsim, 1994, Niedziółka and Zuchniarz 2006]. The subsidies from ARiMR were also included in the calculations of production costs.

Because of the difficulties with estimating the straw production cost, the individual energy cost of straw was calculated in the following way.

It was assumed that the income from grain sales will be used for purchasing straw, which would constitute an additional portion of energy. Next, the total value of the energy acquired from both the planted and purchased straw would be calculated. The individual cost of energy obtained from straw was calculated by dividing the plantation cost (PLN · ha^{-1}) by the summary value of the energy (GJ · ha^{-1}).

Because of the high variability of the straw market price, three levels of prices were assumed: low, medium and high. At the low level, the price of straw was assumed at the level of 110 PLN · t^{-1}, while the medium level – 250 PLN · t^{-1}. These prices were evaluated on the basis of questionnaires and interviews with the representatives of entities purchasing biomass. The high price level was assumed at the value, where the cost of 1 GJ is equal to coal. At the coal price, noted by IERiGŻ (Rynek rolny…2009) at the level of 687.14 PLN · t^{-1} and at the assumed energetic value of coal of 26 GJ · t^{-1}, the straw price will be 450 PLN · t^{-1}. This value was considered as the high straw price level.

The income from grain sales was calculated using two levels of prices: low and high. They were evaluated using the minimum and maximum annual average values of grain purchase prices noted by IERiGŻ at the time of 2004-2009 [Rynek rolny…2005-2009]. The minimal price of winter rape was estimated at the level of 773.9 PLN · t^{-1} and 1223.0 PLN · t^{-1}, for winter wheat, respectively: 417.2 PLN · t^{-1} and 861.2 PLN · t^{-1}, for winter barley: 368.9 PLN · t^{-1} and 777.2 PLN · t^{-1}, and for rye: 280.7 PLN · t^{-1} and 726.1 PLN · t^{-1}.

The briquetting cost was estimated on the example of the Biomasser Maxi Multi briquetting machine of average capacity of 800 kg · h^{-1}, taking into consideration the technical and exploitation parameters and repair costs given by the manufacturer [Długi 2009].

In the briquetting technology, the work of tractor handing the blocks to the shredder was taken into consideration. The tractors exploitation cost was calculated according to the IBMER methodology [Muzalewski 1999]. Yearly use of such tractor was equal to a yearly use of briquetting machine.

The labour cost (2 persons operating the briquetting machine and 1 person operating the tractor) was assumed at the level of 60 PLN · h^{-1} (20 PLN · h^{-1} for each worker).

The calculations of the briquetting costs were performed for four variants of briquette production size. In the variant I it was assumed that the machine will briquette 1000 tonnes of straw per year, in the variant II: 2000 tones, in the variant III: 3000 tones and in the variant IV: 4000 tones.

The calculated costs were increased by 10% for additional costs (secondary costs), connected with the briquetting process, among others: lightning of the building, ventilation, heating and social costs of workers.

The calculated costs were referred to 1 Gj of briquetted straw.

RESULTS

The results of calculations are presented in the tables: 1-5.

Table 1. Costs of energy acquisition from straw before briquetting [PLN · GJ^{-1}]

		straw prices		
	grain prices	Low	Medium	High
Wheat	Low	5.66	10.33	14.53
	high	3.04	6.11	9.43
Rye	Low	8.47	13.39	16.79
	high	4.15	7.77	11.16
Winter rape	Low	7.15	13.03	18.27
	high	4.87	9.48	14.14
Winter barley	Low	6.49	12.10	17.32
	high	3.39	6.91	10.84

Table 2. Straw briquetting costs

Amount of briquetted straw	t · $year^{-1}$	**1000**	**2000**	**3000**	**4000**
Number of working hours	h · $year^{-1}$	1250	2500	3750	5000
Amortization costs	PLN · $year^{-1}$	72 800.00	72 800.00	72 800.00	72 800.00
Cost of exchanging the working elements	PLN · $year^{-1}$	1 833.33	3 666.67	5 500.00	7 333.33
Labour costs	PLN · h^{-1}	60.00	60.00	60.00	60.00
Energy cost	PLN · h^{-1}	35.84	35.84	35.84	35.84
Costs of block loading tractor	PLN · h^{-1}	36.10	35.40	34.98	35.06

Total direct costs	PLN · h^{-1}	191.65	161.83	151.70	146.92
Total direct costs	PLN · year^{-1}	239 556.83	404 577.67	568 864.24	734 619.33
Total costs, incl. indirect costs	PLN · year^{-1}	251 534.68	424 806.55	597 307.45	771 350.30
Briquetting costs	PLN · t^{-1}	251.53	212.40	199.10	192.84
Briquetting costs	PLN · GJ^{-1}	**14.80**	**12.49**	**11.71**	**11.34**

Table 3. Costs of energy acquisition from straw after briquetting [PLN · GJ^{-1}]

Amount of briquetted straw per year: 1000 t				
Plant	Grain prices	Low straw prices	Medium straw prices	High straw prices
Wheat	Low	20.45	25.13	29.33
	High	17.84	18.60	24.23
Rye	Low	23.27	28.18	31.58
	High	18.95	22.56	25.96
Winter rape	Low	21.95	27.82	33.07
	High	19.67	24.27	28.94
Winter barley	Low	21.29	26.89	32.11
	High	18.19	21.71	25.64

Table 4. Costs of energy acquisition from straw after briquetting [PLN · GJ^{-1}]

Amount of briquetted straw per year: 2000 t				
Plant	grain prices	Low straw prices	Medium straw prices	High straw prices
Wheat	Low	18.15	22.83	27.02
	high	15.54	18.60	21.93
Rye	Low	20.96	25.88	29.28
	high	16.65	20.26	23.66
Winter rape	Low	19.65	25.52	30.76
	high	17.37	21.97	26.64
Winter barley	Low	18.99	23.81	29.81
	high	15.10	19.40	23.34

Table 5. Costs of energy acquisition from straw after briquetting [PLN · GJ-1]

Amount of briquetted straw per year: 3000 t				
Plant	grain prices	Low straw prices	Medium straw prices	High straw prices
Wheat	Low	17.37	22.05	26.24
	high	14.75	17.82	21.15
Rye	Low	20.18	25.10	28.50
	high	15.86	19.48	28.50
Winter rape	Low	18.86	24.74	29.98
	high	16.59	21.19	25.85
Winter barley	Low	18.20	23.81	29.03
	high	15.10	18.62	22.55

Table 6. Costs of energy acquisition from straw after briquetting [PLN · GJ-1]

Amount of briquetted straw per year: 4000 t				
Plant	grain prices	Low straw prices	Medium straw prices	High straw prices
Wheat	Low	17.00	21.68	25.87
	high	14.38	17.45	20.78
Rye	Low	19.81	24.73	28.13
	high	15.49	19.11	22.50
Winter rape	Low	18.50	24.37	29.61
	high	16.22	20.82	25.49
Winter barley	Low	17.84	23.44	28.66
	high	14.73	22.19	22.19

The performed analyses allow to state, that the cost of briquetting is between 14 and 33 PLN · GJ-1. The best results are obtained for winter wheat. In the conditions of low straw prices and high grain prices, at the yearly briquetting capacity of 4000 t · year-1, the briquette production cost is 14.38 PLN · GJ-1, which is very attractive when compared to the energy costs of coal. The worst result (33.07 PLN · GJ-1) was calculated for the production of rape straw briquetting, in the conditions of high straw prices and low grain prices at the yearly briquetting capacity of 1000 t · year-1.

CONCLUSIONS

The production of straw briquettes, as the performed analyses show, is profitable mainly in the situation of low straw market prices. An important factor is also a high exploitation of briquet-

ting machine. However, in the conditions of very unfavourable prices of grain and straw, the high exploitation of briquetting machine does not assure profitability of briquette production.

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EKONOMICZNE ASPEKTY PRODUKCJI BRYKIETÓW ZE SŁOMY ZBOŻOWEJ

Streszczenie. Dokonano analizy kosztów pozyskania energii ze słomy w postaci brykietów. Brykietowanie słomy jest atrakcyjne w stosunku do węgla kamiennego ale głównie w sytuacji niskich cen rynkowych słomy. Wysokie ceny słomy jak i niskie ceny ziarna stanowią zagrożenie dla opłacalności brykietowania.

Słowa kluczowe: brykietowanie, energia, biomasa, zboża, koszty, opłacalność produkcji