JAN WIESŁAW DUBAS

PROFITABILITY OF THE CROP OF ENERGY PLANTS IN POLAND ON THE EXAMPLE OF WILLOW OF THE TYPE OF *SALIX VIMINALIS* SP.

Key words: biomass, profitability of willow crop

Introduction

The profitability of agricultural crops depends on many factors, with the following being the most important:
– costs of production means,
– prices of the sale of agricultural products,
– productivity of agricultural land, i.e. the quantity of crops obtained,
– weather conditions in the period of the vegetation of plants.

The profitability of agricultural production has been decreasing in the recent years. It is particularly observed in relation to the profitability calculated per 1 ha of arable lands. If the profitability decreases, the agricultural profits of farmer's families decrease also. It is especially observed in the case of small farms with the traditional agricultural crops. The crops of energy plants were considered to be the ones, which improve agricultural incomes. Below, calculations are presented related to the crop of willow for energy purposes. Apart from the costs of setting up of a plantation, all the numerical data is calculated according to the current costs of production means including the costs of labour force.

The calculations of the costs of 1 GJ of energy in agricultural biomass, which relate to the year 2007 [1], relate to the yield of 285 GJ of potential energy from 1 ha. At that time, three-year yield was harvested from very good agricultural stations. This high yield was achieved in the third cycle of yielding, i.e. after 10 years from the moment when the willow was planted.

The costs and profits presented below related to the yielding of willow crop which was planted in the year 2005, i.e. from the first three-year crop.

In view of the fact that the profitability of agricultural crops is strictly connected with the quantity of the yield obtained, the values received differ significantly from those presented previously.

A yield of ca. 13 tonnes of fresh biomass from 1 ha with an average humidity of ca. 45% was obtained. On average, one tonne of this biomass gives ca. 10 GJ energy. Ca. 130 GJ was harvested from one ha.

Table 1. Costs of obtaining of 1 GJ of energy included in willow biomass (in PLN)

1.	Depreciation cost of setting up of a plantation	6.01
2.	Land tax	0.17
3.	Cost of nurturing: fertilization was not applied	3.47
4.	Cost of cutting	3.85
5.	Cost of grinding down and works transport	5.22
Total direct costs		18.72

Source: Author's own calculations on the grounds of book entries

Re 1: The depreciation cost was calculated as follows:

The cost of setting up of the plantation: PLN 7,805/10 years (annual book deduction of depreciation) = PLN 780.5 / 130 GJ = 6.01 PLN/GJ.

Re 2: The land tax was reduced and is currently PLN 22.00 per 1 ha of arable land PLN 22 / 130 GJ = PLN 0.17 /GJ

Re 3: Weed control costs in the first year after planting amount to a total of PLN 450.00. These costs covered the spray with Targa Super which combats monocotyledon weeds: PLN 450.00 / 130 GJ = PLN 3.47 /GJ.

Re 4: Costs of cutting: PLN 1,500 / 3 years = PLN 500; PLN 500 / 130 GJ = PLN 3.85/GJ.

Re 5: Costs of grinding down and works transport: all the costs including the costs of fuel, labour force, sharpening of blades etc. are covered.

Indirect costs of 12.5% are to be added to the costs calculated this way. Therefore, the total production cost of 1 GJ of potential energy included in willow biomass is as follows: PLN 18.72 + 12.5% x 18.72 PLN = PLN 18.72 + PLN 2.34 = PLN 21.06.

Adding the farmer's profit of ca. 15%, willow biomass can be sold for a price of ca. PLN 23÷25 per 1 GJ. It is a real price comparable with the price obtained in biomass trade. In accordance to my information the thermal power stations, power plants and increasingly more frequently communes are biomass customers, due to its profitability. As a Case Study Świerzawa Commune is chosen.

Case Study: The use of willow biomass as boiler fuel replaces hard coal in Świerzawa Commune.

Biomass producer: WENA, Kochańska-Dubas Jolanta, Attorney Marek Niedzielski, MSc

Table 2. Power of heating devices

Recipient of fuel:	Maximum demand for heat
Świerzawa Communal Culture Centre	40 kW
Primary School in Sokołowiec	220 kW
Junior High School in Świerzawa	100 kW
Primary School in Nowy Kościół	140 kW
Primary School in Świerzawa	150 kW

Source: Author's own collations on the grounds of the documentation from Świerzawa Commune.

The heat demand is ca. 1,200 GJ annually for the heating period running from October to April. In order to produce such a quantity of heat, ca. 68 tonnes of coal with the calorific value of 25GJ/tonne was to be purchased, as the productivity of coal processing into heat in those boilers is ŋ = 0.58.

The direct costs which charge the budget of the Commune are as follows:

1. Purchase of fuel: 68 tonnes x PLN 650= 44,200.00 PLN
2. Personnel which operates the boilers:
   – 2 employees x 6 months
   – 12 months x PLN 4,000 = 48,000.00 PLN
3. Current repairs and overhauls: PLN 5,000.00
4. Utilization of ash: 15% from 68 tonnes = 10.20 tonnes; 10.20 tonnes x PLN 110 = 1,122.00.

The total cost of production 1,200 GJ = 98,322.00 PLN, i.e. the cost of 1 GJ of heat for the Commune was PLN 81.94.

To produce the same quantity of heat, i.e. 1,200 GJ, ca. 100 tonnes of biomass has to be purchased because the productivity of biomass processing into heat in these boilers is ŋ=0.87. In this case, the direct costs which charge the budget of the Commune are as follows:

1. Purchase of fuel: 100 tonnes x PLN 322 = PLN 32,200
   (PLN 322.00 results from 14 GJ in 1 tonne x PLN 23.00/GJ)
2. Operation: none – self-service boilers with fuel containers
3. Current repairs and inspections: PLN 10,000
4. Utilization of ash: none. Ash in the quantity of 1% is used as a potassium and phosphorus fertilizer and is removed in the course of services.

The total production cost of 1,200 GJ equals 42,200.00 PLN i.e. the cost of 1 GJ of heat for the Commune is PLN 35.17.

In the comparison above, the remaining costs such as depreciation costs, fixed costs etc. were not taken into consideration. An essential element connected with environmental protection was not taken into account, either.

During the combustion of 68 tonnes of hard bituminous coal, 136 tons of CO_2 were produced.

During the combustion of biomass, the balance of CO_2 was harmonized and proved to be positive, because biomass in this quantity was produced on the surface of 8 hectares; assuming that 1 ha of willow absorbs annually 70 tonnes of CO_2, 70 x 8 = 560 tonnes of CO_2 were absorbed from the atmosphere.

The aspect of savings is very important for the Commune. The replacement of traditional coal boilers with biomass boilers brings about savings in the amount of above PLN 50,000 per year for the Commune. Such a solution can be a guiding example for other communes in Poland. It is to be emphasized that the transport of unprocessed biomass should take place within a radius of 8 km. A similar example for one agricultural family has been provided.

Case Study: A business model for an agricultural family under Polish conditions

All the calculations are based on heat unit costs: cf. Table 3.

In Polish condition, one agricultural family consumes annually ca. 120 GJ of energy for the heating of house rooms in the period of autumn, winter and spring + heating of water all the year round, and frequently also to cook meals.

Table 3. Unit costs of heat

Type of fuel	Heat of combustion	Unit cost of heat in the purchased fuel	Unit cost of heat produced taking into consideration efficiency
Fuel oil	43 GJ/tonne	PLN 81.40 /GJ (~PLN 3,500.00 /tonne)	PLN 90.43 /GJ (ŋ=0.9)
Natural gas	34,6 GJ/1000 m^3	PLN 80.92 /GJ (~PLN 2,800.00 /1000m^3)	PLN 89.91 /GJ (ŋ=0.9)
Hard coal	25 GJ/ tonne	PLN 27.20 /GJ (~PLN 680.00 /tonne)	PLN 46.90 /GJ (ŋ=0.58)
Coal dust	22-23 GJ/ tonne	PLN 23.26 /GJ (~PLN 500.00 /tonne)	PLN 31.01 /GJ (ŋ=0.75)
Shrubby willow	18 GJ/ tonne	PLN 25 /GJ (~PLN 450.0 /tonne)	PLN 28.74 /GJ (ŋ=0.87)
Straw	15 GJ/ tonne	PLN 11.33 /GJ (~ PLN 170.00/ tonne)	PLN 13.33 /GJ (ŋ=0.85)

Autumn 2009
Source: Author’s own calculations.

This energy can be purchased in the form of gas or fuel oil, and then they have to pay ca. EURO 2,700 for it (120 GJ x EURO 22.50 = EURO 2,700). This consumption is expensive and only prosperous farmers can afford it. On the other hand, such a method of the heating of the house and the provision of warm water is very convenient. It is not time-consuming. There is no problem with ash. It is an expensive yet slightly more ecological (less CO_2 emission) method of the farmstead heating.

The combustion of hard coal or coal dust is yet another method to obtain heat. It is the most popular medium of house energy. In Poland, it has been used for a very long time because it has been extracted in large quantities. It is estimated that in Poland, ca. 20 million tonnes of coal: 9 million tonnes in households in agriculture and ca. 11 million tonnes in cities are used in households. Assuming that 1 tonne of coal used produces ca. 2 tonnes of CO_2, only agricultural households emit 18 million tonnes of CO_2. This quantity can be very easily reduced through the popularization of the use of willow biomass instead of coal. The production of heat from biomass is considerably cheaper because, if the farmer purchases coal, he/she must pay 120 GJ x EURO 11.7 for it, i.e. ca. EURO 1,400 plus the transport costs of fuel. Obviously enough, the combustion of coal involves work connected with the operation of the boiler and utilization of ash. Instead of this fuel, willow can be used. Its cost will be many times lower because even 0.6 hectare of high-energy willow can completely replace coal. This fuel is certainly labour-consuming, yet the greatest expense of work coincides with the winter period, which is the period in agriculture where there is no vegetation, and owing to this, the farmer has a lot of free time. One needs to be prudent and the fuel should be prepared one year before its use. Willow biomass is a clean fuel and involves almost no costs. In Table 3, the unit cost of 1 GJ was provided if one were to buy willow biomass. If a farmer produced it in his own farm, this would then be a single cost connected with the setting up of a plantation, i.e. ca. EURO 400. In the case of a further plantation extended up to 0.6 ha, the farmer would have to engage his own labour. No emission of CO_2 is a significant argument; the research indicates that 1 hectare of the willow crop absorbs annually ca. 70 tonnes of CO_2 i.e. as much as the emission of this gas during the combustion of biomass from this area.

The purchase of an appropriate boiler must be a significant cost to be incurred by the farmer. However, this expense pays for itself very quickly. Ash from the combustion of biomass constitutes a very good potassium and phosphorus fertilizer.

Both real calculations were included in Benwood FP7 Project no. 227321, where they obtained positive recommendations for other European and non-European countries.

Summing up the above calculations, it can be found that the profitability of the crop of energy willow in the non-processed form (e.g. coal form *Cito*!: or „CC" *Cito Carbon* torrefied pellets) is limited to local applications. It is profitable to crop the willow for the self-supply of the farm or to supply it to local boiler houses. The transport costs are very high and it damages the profitability of this agricultural production, as it was demonstrated in many publications [2, 3, 4].

In view of the fact that there is no organized market of biomass with supplies for large professional power industry, such an activity is also non-profitable; all the more so because the subsidies for energy plants are to be reduced starting from the year 2011.

References:

1. *Dubas J.W., Koszty* pozyskania biomasy wierzbowej, [w:] *Regenerative Energie in Polen und Deutschland im Perspctive bio 2020*, Koszalin – Torgelow 2008, pp. 29–36.
2. Dubas J.W., *Pelety nowej generacji*, [w:] *Energetyczne wykorzystanie biomasy w działalności gospodarczej*, Koszalin 2009, pp. 247–256
3. Dubas J.W., *Toryfikacja – proces bliskiej przyszłości*, [w:] *Planowanie i zarządzanie w energetyce*, Wydawnictwo SGGW, Warszawa 2009.
4. Dubas J.W., *Stan i kierunki rozwoju biomasy dla potrzeb elektroenergetyki polskiej*, [w:] *Odnawialne źródła energii w świetle globalnego kryzysu energetycznego*, Difin, Warszawa 2010.