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USE OF ENERGY WILLOW FOR THE PRODUCTION OF ENERGY IN THE PODKARPACKIE PROVINCE

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Abstract. The paper presents an analysis of surveys conducted in companies using willow *Salix Viminalis* for energy production in the Podkarpacie province, it shows that companies are interested in the production of energy from biomass. The use of willow as a renewable energy source for the production of energy from biomass is a very good solution. The respondents claim that insufficient number of producers of willow, and thus, insufficient amounts of product delivered, is a barrier, inhibiting the development of their companies. To increase the amount of biomass purchased from farmers, the companies intend to encourage biomass producers to keep and expand existing plantations by awarding them permanent contracts to provide energy willow. All companies prefer biomass in the form of wood chips, but are aware of the lack of appropriate harvesting machinery and drying equipment. These factors affect the quality and price of wood chips, which is quite high from the viewpoint of manufacturers.

Key words: energy willow, energy production and use of biomass, energy plantations

INTRODUCTION

In the process of energy production replacing fossil fuels with biomass contributes to the slowdown of adverse climate change. The European Union demanded Poland to sign the directive, which obliges us to achieve a 15% share of renewable energy in total energy consumption by 2020. In Poland, the main source of obtaining biomass is wood, cereal plants and energy crops plantations. The willow *Salix Viminalis* is a locally--grown plant which is adapted to the soil and climatic conditions in Poland; its main feature is its high energy efficiency. Therefore, more and more local farmers grow it for sale, as well as for their own needs.

Awareness of the benefits of using biomass for energy production in our society is increasing, which leads to an increasing number of energy willow plantations (and other energy plants) in Poland and growth in biomass use in energy-producing plants.

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The paper presents an analysis of surveys conducted among five plants using willow Salix Viminalis to produce electricity and/or thermal energy in the Podkarpacie province. These are plants whose maximum production capacity ranges from 3.5 MW to 450 MW – electric power and to 875 MW – thermal power.

Analysis of the research has identified a real interest in biomass and benefits of its use among energy-producing plants. This questionnaire survey showed what expectations the plants have towards producers of biomass and how they encourage farmers to establish and expand their plantations.

MATERIAL AND METHODS

The study was based on the survey on activities in the electricity producing plants and/or those producing thermal energy; it collected information about buying and burning willow and other facts related to the willow tree and its use by manufacturing plants. The survey included 29 questions. The survey was conducted among the five plants using willow in the Podkarpacie province.

The following plants participated in the survey:

1 – The plant with a maximum production capacity of 450 MW of electrical and 875 MW of thermal power

2 – The plant with 2 boilers with a power of 4 MW each

3 – The plant that produces 20 MW of thermal energy

4 – The plant that produces 5 MW of thermal energy

5 – The plant that has a boiler with a power of 3.5 MW.

RESULTS

All the surveyed plants have their own energy willow plantations ranging from 2 to 43 hectares, 40% of them have a plantation with the area of 10.1 to 20 hectares. Other plants have plantations respectively with the area of 2-5 hectares and 5.1-10 hectares, plant 2 has the largest plantation, with the area of 43 hectares (Table 1).

In the available literature there is a lot of information about the amount of willow biomass crops as dry mass per 1 ha of cultivated area. [Ciechanowicz 2001, Szczukowski and Tworkowski 2000, Szczukowski et al. 2005]. Polish authors define the crop from 1 ha at 15-22 tons of dry mass. However, note that the production of dry mass depends on many factors, including: frequency of harvests, number of planted seedlings, habitat conditions, fertilization and weather conditions. The study shows that the production of dry mass on the largest plantation, owned by plant 2, is above 20 $(t \cdot ha^{-1}) \cdot year^{-1}$. In other plants dry mass is estimated at 15-20 $(t \cdot ha^{-1}) \cdot year^{-1}$ (Table 1). Thus, the yield obtained by them is at an appropriate level.

The survey shows that interest in willow cultivation among farmers is mostly low, this is certainly due to the fact, that, according to various sources [Izdebski and Skudlarski 2004, Dubas et al. 2004, Dubas and Tomczyk 2005, Szczukowski et al. 2004, Kwaśniewski 2011] the start-up cost for 1 hectare of energy willow plantation on agricultural soils ranges from 5000 PLN to 10 000 PLN. However, note that in subsequent years the costs are much lower, but it takes more time to recover them (from a few to

Table 1. Information on plantations operated by energy producing plants
Tabela 1. Informacje o plantacjach prowadzonych przez zakłady produkujące energię

Plant Zakład	Area planted, ha – Wielkość plantacji, ha				Production of dry mass ($t \cdot ha^{-1}) \cdot year^{-1}$ Produkcja suchej masy ($t \cdot ha^{-1}) \cdot rok^{-1}$	
	2-5	5.1-10	10.1-20	Larger – how many hectares? Większe – ile hektarów?	15-20	above 20 powyżej 20
1			x		x	
2				43		x
3			x		x	
4	x				x	
5		x			x	

more than ten years). For farmers cultivation of willow is associated with a much greater risk than in case of annual food crops; this has been confirmed by many authors [Matyka 2008, Stolarski 2009, Grzybek and Muzalewski 2010]. However, an upward trend can be observed.

All the surveyed plants buy willow from local farmers.

Buying from willow farmers

Most plants (60%) have been buying willow for 2-5 years. 20% of the surveyed plants have been buying willow for 1 year. The same number of plants for 5-10 years. None of the plants has been buying willow for more than 10 years – it shows that energy production from biomass is only just developing (Table 2).

All the surveyed plants buy willow taking its weight and humidity into consideration. Prior to purchase, each plant collects samples for testing to determine the energy value that can be obtained from the purchased biomass.

Table 2. How long willow has been bought by plants
Tabela 2. Od kiedy zakłady skupują wierzbę energetyczną

Plant Zakład	Time, years – Czas, lata			
	for 1 year od 1	2-5	5-10	above 10 powyżej 10
1			x	
2		x		
3		x		
4	x			
5		x		

Biomass is bought by weight, so its price is given depending on the humidity in PLN·t^{-1} (Table 3). All the surveyed plants buy biomass with varying degrees of humidity. Willow with humidity of 60-50% is regarded as moist, with humidity of 40-30% as slightly dried and with humidity of about 25-20% is the dry biomass. Plants prefer to buy dry willow, that is ready to be burnt, however, manufacturers are not able to supply it in such a form. Most often moist willow is bought at an average price of 124 PLN·t^{-1} and slightly dried at an average of 224 PLN·t^{-1}. Price of dry wood chips amounts to, on average, 270 PLN·t^{-1}. Samples collected at purchase are also used to determine its humidity and on this basis, willow is classified as moist, slightly dried or dry.

Table 3. Purchase price taking into account wood chips' humidity
Tabela 3. Cena skupu zrębki z uwzględnieniem wilgotności

Plant Zakład	Cena, zł·t^{-1} – The price, PLN·t^{-1}		
	moist wilgotna 60-50%	slightly dried podsuszona 40-30%	dry – sucha 25-20%
1	120	240	280
2	120	220	270
3	130	230	270
4	120	210	260
5	130	220	270

The average annual purchase of wood chips depends on the size of the plant. Among plants that use willow for energy production there is one that buys up to 100 000 tons of dry mass per year. In comparison, other plants buy small amounts of biomass; from 500 to 20 000 tons (Table 4).

Table 4. Amount of dry pulp purchased during a year in surveyed plants
Tabela 4. Ilość skupowanej suchej masy drzewnej w ciągu roku w badanych zakładach

Plant Zakład	Amount of dry mass purchased, tons Ilość skupowanej suchej masy, tony			
	up to – do 500	501-1000	1001-2000	More – how many tons? Więcej – ile ton?
1				up to – do 100 000
2				3 000
3				20 000
4			x	
5		x		

All plants that were surveyed indicated their willingness to increase the volume of bought willow in the future. This is due to legal requirements and benefits of biomass burning, lower cost of energy production in comparison with coal or gas [Owoc and Walczyk 2011], environmental benefits, especially the reduction of CO_2 emissions.

The surveyed plants sign permanent contracts for the provision of energy willow. It is an appropriate policy of plants which aims to stabilize the supply market of biomass.

Characteristics of plants using biomass for energy production

Energy producers would prefer to buy energy willow in the form of chips that are ready to be burnt. However, the small producers of willow cannot afford to buy suitable equipment, namely, chippers and dryers to deliver wood in the form of chips ready for burning. Therefore, all plants (Table 5) that purchased willow dry it on their own premises by means of prolonged storage. Surveyed plants also buy a portion of willow in the dried form. None of them burn wet biomass.

Table 5. Ways of drying willow
Tabela 5. Sposoby podsuszania wierzby energetycznej

Plant Zakład	Ways of drying – Sposoby podsuszania			
	active aktywne	prolonged storage przez dłuższe składowanie	purchase of the dried form skup podsuszonej	burn wet spalanie mokrej
1	x	x	x	
2		x	x	
3		x	x	
4		x	x	
5		x	x	

Handling of wood chips in most plants is done by the loader. Only one plant, plant 1, is automated and has a store with a mobile bottom, which automatically feeds the boiler. It does not need any additional service because the boiler operation is fully automated. Other plants require additional service during boiler operation. However, in the near future, plants do not plan any changes regarding loading of biomass to the boiler.

All the surveyed plants have traditional boilers, whereas plants 1, 2 and 3 have additional special boilers designed to burn willows.

Willow can be burned alone or with coal and coal dust. Willow itself is burned in plants 1 and 3. All other plants burn it with coal, whereas plant 2 and 3 with coal dust (Table 6).

All plants reported savings after the introduction of willow. First of all, emission of CO_2, dust and ash was reduced, compared to burning fossil fuels. Plant 1 has stopped paying excise tax since the introduction of willow. This plant is the only one to sell green certificates.

Table 6. Ways of burning willow in surveyed plants
Tabela 6. Sposoby spalania wierzby w badanych zakładach

Plant Zakład	The way burning of willow Sposób spalania wierzby		
	on its own sama	with coal z węglem	with coal dust z miałem węglowym
1	x	x	
2		x	x
3	x	x	x
4		x	
5		x	

Energy produced from biomass is used in most plants throughout the year, just one uses it only during the heating season (plant 5). Energy produced from biomass is offered for sale in four plants. Plant 5 does not sell it, the produced energy is used for its own purposes. Plant 3 uses the energy produced from biomass for its own purposes, but also offers it for sale (Table 7).

Table 7. Use and intended purpose for energy produced from biomass
Tabela 7. Wykorzystywanie i przeznaczenie produkowanej energii z biomasy

Plant Zakład	Period of use of energy produced Okres wykorzystywania wyprodukowanej energii		Intended purpose for energy produced from biomass Przeznaczenie wyprodukowanej energii	
	all year round przez cały rok	only during the heating season tylko w okresie grzewczym	own needs własny użytek	sale sprzedaż
1	x			x
2	x			x
3	x		x	x
4	x			x
5		x	x	

As barriers to the development of plants towards wider use of willow, the surveyed see the high price paid for the willow, a small number of manufacturers and low quantity of delivered product. In addition, lack of proper equipment for drying and burning, and suitable machinery for harvesting are considered as other obstacles by the surveyed.

For three out of five surveyed plants willow is the only energy plant that they use. Plant 1 apart from the willow utilizes also poplars from plantations, whereas plant 3 uses also Virginia fanpetals (*Sida hermaphrodita Rusby*).

All the surveyed plants have increased employment, since they started using willow wood chips, plant 1 by 3-4 people, and the others recruited additional 1 or 2 persons.

CONCLUSIONS

1. An analysis of surveys conducted among plants using willow *Salix Viminalis* for energy production in the southern Poland shows that plants are interested in the production of energy from biomass. The surveyed think that the use of willow as a renewable source of energy for energy production from biomass is a very good solution.

2. The willow *Salix Viminalis* is the locally-grown plant which is adapted to the soil and climatic conditions in Poland. Thanks to its limited requirements, it is possible to use agricultural land, excluded from production of food crops, often with high production potential, but periodically excessively humid or polluted by industry. The willow also has high energy efficiency.

3. As a barrier, inhibiting the development of plants towards the use of willow, the surveyed considered too small number of producers, and thus too low amount of delivered product. To increase the amount of biomass purchased from farmers they intend to encourage farmers to keep and expand existing plantations by signing permanent contracts with them for the provision of energy willow.

4. All plants favour biomass in the form of ready-made chips, however, are aware of lack of appropriate machines for harvesting and drying equipment. These factors affect the quality and price of wood chips. From the point of view of energy producers this price is quite high.

5. The surveyed plants are aware of the benefits of burning biomass, which does not cause the greenhouse effect and acid rain, compared with the burning of fossil fuels.

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WYKORZYSTANIE WIERZBY ENERGETYCZNEJ DO PRODUKCJI ENERGII NA TERENIE WOJEWÓDZTWA PODKARPACKIEGO

Streszczenie. W pracy przedstawiono analizę przeprowadzonych badań ankietowych wśród zakładów wykorzystujących wierzbę energetyczną *Salix Viminalis* do produkcji energii na terenie województwa podkarpackiego. Wykazuje ona, że zakłady są zainteresowane produkcją energii z biomasy. Wykorzystanie wierzby energetycznej jako odnawialnego źródła energii (OZE) do produkcji energii z biomasy to bardzo dobre rozwiązanie. Ankietowani odbiorcy jako barierę hamującą rozwój zakładów uznali zbyt małą liczbę producentów, a tym samym i dostarczanego produktu. Chcąc zwiększyć ilość biomasy skupowanej od rolników, zamierzają zachęcić producentów do prowadzenia i powiększania istniejących plantacji przez podpisanie z nimi stałych umów na dostarczanie wierzby energetycznej. Wszystkie zakłady preferują biomasę w formie gotowej zrębki, ale zdają sobie sprawę z braku odpowiednich maszyn do zbioru oraz sprzętu do osuszania. Te czynniki wpływają na jakość i cenę zrębki, która jest dość wysoka z punktu widzenia producentów.

Słowa kluczowe: wierzba energetyczna, produkcja i wykorzystanie energii z biomasy, plantacje energetyczne

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